Risk Governance within Complex and Uncertain Environments

A Retrospective Analysis of the Regional Citizens' Advisory Councils in Alaska

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ABSTRACT

Technology is a double edged sword that presents both social opportunities and risks. Mineral industries rely heavily on technology during extraction, transportation, and waste management activities. Water contamination from chemical spills or byproduct leakage is a widespread concern because it threatens cascading environmental, financial, and health impacts to regional communities. Risk management is difficult because the technological, environmental, and human systems are complex and tightly coupled. Uncertainty is often high due to irreducible complexity and limited predictability.

These complex and uncertain risks demand a new risk paradigm that broadens the thinking towards “risk governance” and leverages greater public involvement. This paper uses the International Risk Governance Council (IRGC) framework to conduct a retrospective multi-framework analysis on a system that has implemented the new paradigm to risk governance. The Alaskan oil terminal and tanker system has institutionalized permanent Regional Citizens’ Advisory Councils (RCACs) to work directly with industry and regulatory agencies to manage oil spill risks. The retrospective analysis identifies the important components of the risk context, development, and design that have contributed to risk management improvements. The case study concludes that a new risk paradigm that integrates greater public participation can reduce risk and increase resiliency in complex and uncertain environments.

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I. Introduction

Current mineral extraction activities involve technological and environmental risks that are inherently complex, uncertain, and controversial. The rapid implementation of innovative technology further exacerbates the risk management challenges. Some scholars have suggested that a new risk governance paradigm is needed to deal with the unique challenges presented by such situations. Public participation is an integral component of the new risk governance paradigm. However, it is unclear exactly how public participation should be integrated or how the new risk paradigm should be structured. Even if the design were clear, others argue that a risk paradigm shift would require such extreme institutional changes that it is not feasible.

This paper uses a case study approach to examine a risk system that has already shifted towards a new risk governance paradigm. The risk governance system surrounding the Alaskan oil terminals and tanker transportation has institutionalized two independent regional citizens' advisory councils (RCACs). The RCACs are influential stakeholders in risk assessments, risk management decisions, and ongoing risk vigilance. With their creation, the risk governance system has become a model for a new risk paradigm. As such, this paper conducts a retrospective multi-framework analysis of the Prince William Sound Regional Citizens' Advisory Council (PWSRCAC) to draw lessons for other similar technological-environmental risk systems.

The following sections begin with a brief overview of the risk challenges related to mineral industries that involve overlapping technological and environmental systems. It then provides an in-depth examination of the current risk assessment and risk management limitations which support the need for a new risk paradigm. Then, the paper reviews the gradual shift towards a new risk paradigm that incorporates public participation. Finally, the case study is presented. The analysis draws on the International Risk Governance Council (IRGC) framework and examines the important components of the risk context, development, design, and outcomes. The case study illustrates the positive outcomes of a more participatory governance system and identifies the critical components necessary for its successful implementation.

A. Mineral Industry Risk Challenges

Mineral resource activities present both an economic opportunity and technological risk for regional communities (Steiner 2007). The industry influx diversifies local economy, creates jobs, and contributes to both private and public revenues. However, the sudden change in local activity is often accompanied by unintended consequences or negative externalities. Water contamination is a widespread concern associated with unknown or unanticipated chemical releases during extraction, transportation, and/or waste disposal. Occurring by accidental spills or byproduct leakage, contaminated water resources threaten cascading health, financial, and psychological impacts to regional communities. To ensure communities obtain the benefits from industry opportunities, risk management needs to adequately identify and reduce environmental risks (International Risk Governance Council 2005).

Mineral industries vary by commodity (oil, natural gas, copper, etc.), location (offshore or onshore), and type (conventional/unconventional, low grade/high grade). Most activities share a strong reliance on complex technological systems to acquire benefits and abate risk. However, these systems create unique problems for the traditional risk paradigm because technological risk often involves high uncertainty, social discontent, elevated risk perception, and low probability, high consequence events (Kammen & Hassenzahl, 2001; Rasmussen, 1990). Additional challenges emerge from innovative technology that expands production into new sources, such as shale and tar sand reserves. Innovative technologies are often utilized in new environments, both lacking the historical data necessary for predictive risk assessments (Aven and Renn 2009, Perrings 1989).

Technological and resulting health and environmental risks are embedded in a larger social and political context that influences the related policy and management decisions (Klinke and Renn 2002). However, the predominant risk paradigm intentionally establishes a divide between science and society. It expects that "scientific analysis of risks can control uncertainty, defeat ignorance, and provide indisputable input for appropriate regulation" (De Marchi 2003). Consequently, the regulatory system requires that risk assessments are based primarily on scientific facts (Byrd and Cothern 2000). Broader society is not often included because of perceived technological incompetence and subjective values.

Current risk management challenges call to question the scientific authority established by the traditional risk paradigm. Scientific disagreement among experts, stakeholder value conflicts, public distrust, and political delay tactics are prevalent (Whitfield, et al. 2009). Conflicting positions are forced to argue the science instead of the embedded values and uncertainty because the current risk paradigm is not structured to allow constructive deliberation among diverse perspectives (Klinke and Renn 2002). Stakeholder groups often produce independent risk assessments in attempts to disprove previous results and expose conflict of interests (Busenberg 1999b). As uncertainty increases, the deviation among expert opinion grows as well (Aven and Renn 2009).

While risk assessment and management were historically conceived as separate processes, they are actually intertwined and partially overlapping (De Marchi 2003). Technological risks further blur the line between risk assessment and management because they depend on human behavior and management to maintain ongoing safety. Human and managerial error are direct sources of risk within the system (Merrick, et al. 2005). Reducing risk requires comprehensive and relevant risk assessments, effective decision-making processes, and ongoing risk vigilance.

A new risk paradigm is necessary to unveil scientific values judgments, systematically integrate broader deliberation, and ensure vigilant risk management (Renn and Klinke 2004). To do so requires a broader system perspective that acknowledges the surrounding governance structures that affect risk assessment and management decisions. Risk governance is a concept and tool that integrates these traditionally separate processes while expanding to include broader social and organizational factors that affect the risk outcomes (International Risk Governance Council 2005).

Risk governance recognizes that issues of governance and risk are interrelated in an inseparable system (De Marchi 2003). The risk governance system is complex and the interactions contribute to its ability to manage risk appropriately. Ignoring the interconnections or any source of information can lead to unintended consequences or even disasters (De Marchi 2003). Risk governance needs to be systematically analyzed to gain a more comprehensive risk picture and identify appropriate management needs. According to Renn (2009),

> "…risk governance is based on a normative belief that the integration of knowledge and values can best be accomplished by involving those actors in the decision-making process that are able to contribute all the respective knowledge as well as the variability of values necessary to make effective, efficient, fair, and morally acceptable decisions about risk."

As a tool, risk governance directs the type and source of information used in the decision making processes (International Risk Governance Council 2005). The economic sector, scientific community, and government agencies routinely contribute expert information from their respective fields (Renn and Schweizer 2009). However, despite being the best representatives of social values, public stakeholders have a more limited and voluntary role in risk governance. Acknowledging the pervasiveness of values in complex risk management systems is a call for action for an increased involvement of public stakeholders.

Through institutional and procedural changes, risk governance can promote broader integration of pertinent information and enhance communication among represented interests. A shift towards a more participatory system with greater public access could also reframe the dichotomy between science and society (De Marchi 2003). Integrating greater public participation has the potential to reduce systematic risk while simultaneously improving institutional trust and adhering to democratic ideals. However, a new risk paradigm requires a type of public participation that may need to be institutionalized into the governance system (Reed 2008). It is unclear in which instances such an elaborate shift is most necessary, how it could develop, and what it would look like. Instead of postulating answers, this paper examines a system that has already shifted towards a new risk governance paradigm.

B. Risk Assessment Limitations

The traditional risk paradigm maintains separation between risk assessment and risk management (Wu and Farland 2007). Risk assessment is focused on deriving facts that can be used to inform risk management decisions. It often relies on quantitative methods and scientific experts to reduce uncertainty. In contrast, risk management is focused on using information to make decisions that support societal values. It relies on politicians and stakeholders to implement policies. The separation between assessment and management is intended to protect scientific facts from manipulation by social values (Byrd and Cothern 2000). It assumes that scientific risk assessments can be conducted without value judgments and that risk management can choose appropriate policies based on scientific evidence (Byrd and Cothern 2000). In complex situations however, these assumptions are erroneous and cause significant risk management challenges (Ludwig et al. 1993). When this occurs, the risk governance system can add exogenous risk into an already vulnerable system (Renn and Klinke 2004).

Risk assessments are directed by important value judgments such as the determination of which risks to assess, when to initiate an assessment, what methodology to use, and how to interpret the results (Byrd and Cothern 2000). These decisions require more than just scientific evidence. They require value judgments that reflect the interests and concerns of society. For example, a scientific assessment is of little use if it is not considered a risk problem in the first place. Further, the results are of limited use if the acceptable level of societal risk is unknown. Regardless, these decisions have traditionally been disguised within scientific assessments and protected from broader deliberation (De Marchi 2003).

These broad decisions, such as problem definition and acceptable risk, are critical value judgments that affect risk management decisions (Aven and Renn 2009, Byrd and Cothern 2000). In complex systems, value judgments are particularly important because irreducible uncertainty is dealt with using scientific assumptions. Complex systems are vulnerable to high uncertainty because multidirectional causal pathways, interactive effects, and delayed responses are difficult to assess. Quantitative modeling is often not capable of reducing uncertainty to a necessary level to make confident and accurate risk predictions (Aven and Renn 2009, Ludwig, Hilborn and Water 1993).

Value judgments are associated with the assumptions used to cope with uncertainty. However, small assumption differences can lead to drastically different results (Aven and Renn 2009). Secondary uncertainty arises when results are highly sensitive to different assumption inputs. It can create a challenge for risk management because the associated value judgments are disguised within the technical details of the scientific assessment. Frequently, risk managers rely too heavily on the results without examining the underlying assumptions. As a result, poor decisions are implemented and stakeholder conflict grows. For these reasons, complex risks with high uncertainty require a broader assessment that moves beyond purely “science-based” risk assessment paradigms (Aven and Renn 2009). Values and uncertainty need to be unveiled to allow a more constructive and transparent deliberation (De Marchi 2003).

Technological risks are susceptible to another source of uncertainty transpiring from system unpredictability (Aven and Renn 2009). With prolific causal links and variable interactions, complex risk systems have an incalculable number of risk pathways that can potentially lead to risk events. Many of these risk pathways may not be reflected in past events, but are equally likely to occur (Aven and Renn 2009). However, predictive risk assessments usually rely on historical and current data to determine risk. Potential risk pathways that have not occurred are left out of the analysis. The resulting predictive models rarely provide a comprehensive or accurate reflection of the system risk. The reliance on historical evidence to predict future consequences is a critical limitation of traditional risk assessments. It marginalizes low probability, high risk events and underestimates accumulating effects (Aven and Renn 2009).

Aven and Renn (2009) describe low probability, but high impact events as black swan incidents. Black swan events can have disastrous consequences, but are probability outliers that complicate traditional risk assessments. They include oil spills, such as Exxon Valdez Oil Spill, and nuclear disasters, such as Chernobyl disaster. Compared to other risks, black swans are unique because of the high public risk perception associated and the accumulating risk pathways that need consideration. First, the public often perceives black swan events with higher risk than traditional quantitative risk assessments indicate (Slovic 1987). The discrepancy between these risk perceptions indicates important social values that are not usually considered in the analysis. Some characteristics valued by the public, but rarely included in risk assessments, include whether the risk is involuntary, delayed, unknown, uncontrollable, unfamiliar, potentially catastrophic, dreaded, and/or especially severe (Klinke and Renn 2002, Slovic 1987). Black swan events exhibit many of these risk characteristics not incorporated in the traditional risk assessments.

Another concern regarding black swan events is that they can result from numerous risk pathways. Since complex risks have numerous interconnected causal factors, the number of risk pathways leading to severe consequences has the potential to be quite high (Aven and Renn 2009). For example, if there are one million risk pathways possible, each with a one in a million chance of occurring; then, the system should expect any one of them to actually occur every year. Additionally, historical data cannot predict all the potential risks pathways leading to a black swan event because most have not occurred in the past (Aven and Renn 2009, Perrings 1989). By definition, such outliers are outside regular expectations and patterns.

In summary, scientific evidence and value judgments are inseparable aspects of risk assessments (Kuzma and Besley 2008, Byrd and Cothern 2000). While rarely acknowledged, value judgments are crucial for problem definition, risk interpretation, and addressing uncertainty in complex systems. The scientific conflicts among experts and stakeholders are often focused on methodology, related assumptions, and opposite values of risk ranges. However, these conflicts are often fueled by underlying value differences (Byrd and Cothern 2000). The separation between risk assessment and risk management is blurred when values are acknowledged throughout the entire process (Byrd and Cothern 2000). Integration between these processes could lead to more informative assessments and improved risk management.

C. Risk Management Limitations

Risk management is the process of reducing risk to a level deemed acceptable by society and to assure control, monitoring, and public communication (Klinke and Renn 2002). The ultimate goal is to reduce the occurrence and severity of unintended consequences resulting from human activity (Aven and Renn 2009). Risk managers must rely on the information available from risk assessments to make decisions. However, traditional risk assessments do not include broader information regarding the risk management factors within a system that can amplify and attenuate risk. It is assumed that once the proper information is provided, risk policy will be implemented, monitored, and enforced with vigilance. To the contrary, most environmental disasters are triggered from organizational weakness and human error (Merrick et al. 2005). Combating complacency and establishing risk vigilance are important aspects of reducing the likelihood and severity negative consequences (International Risk Governance Council 2010).

1. Incentives

Despite the traditional limitations, quantitative risk assessments are useful tools that increase the available knowledge for risk managers. The limitations are related to the false confidence they endorse and the narrow perspective they use. For the same reasons, quantitative assessments have precedent in regulatory policy design because they are often consistent, transferable, and defendable (Aven and Renn 2009). However, government agencies cannot feasibly conduct a risk assessment and implement regulatory policy for every risk within complex systems. There are too many possible risk pathways, changing conditions, and transaction costs. Instead, market-based policies have been designed to incentivize industries to initiate private risk assessments and management strategies (Ferreira et al. 2004).

Private companies do not typically have an inherent incentive to prevent or limit negative environmental externalities because most natural resources are public goods (Costanza 1990, Ferreira et al. 2004). To amend this situation and ensure appropriate risk management around public resources, numerous policies have been designed to align private and public interests. Some common policies include financial incentives, liabilities and financial assurances.

Industry is expected to consider the potential litigation costs related to any business strategy, including risk negligence. However, information and intertemporal uncertainties make it difficult to consider potential future costs in present accounting decisions (Costanza 1990). Since private companies have more experience and financial resources available for litigation than most potential plaintiffs, there is less financial risk associated with litigation (Boyde 2002). The resource discrepancy is exacerbated by the fact that the public has the burden of proof to show damages, which can be difficult or even impossible in complex systems (Costanza 1990).

Financial assurance attempts to overcome the intertemporal and burden of proof obstacles associated with liabilities (Costanza 1990). The policy forces private companies to demonstrate restoration funds prior to initiating certain activities that have the potential to damage public goods. As a result, the burden of proof transfers onto the private company, which must demonstrate restoration before reacquiring the frozen financial assets. Since potential future costs appear in present accounting, profit decisions are expected to promote risk reduction and safer innovations (Constanza 1990).

In actuality, financial assurance is less effective for complex and uncertain risks because it requires tailored policies that adapt to changing conditions. Design limitations include the upfront financial requirement, mechanisms allowed, conditions when returned, and interaction with other laws (Boyde 2002). Practical experiences illustrate that the financial amount required upfront is rarely sufficient to cover the intended costs (Boyde 2002, Shogren et al. 1993). The established amount needs to be adjusted to reflect new information and annual inflations, but it is not always done (GAO 2011). In highly complex and uncertain environmental, policies intended to incentivize risk reductions fail to reach theoretical expectation because of caveats during implementation (Shogren et al. 1993).

2. Oversight

Regulatory oversight is responsible for policy implementation, ongoing monitoring, and initiating new risk assessments. A broad perspective of oversight includes the government regulatory agencies, Congress, industry, media, and stakeholders. The oversight design can affect technology development, individual and collective interests, and public trust (Kuzma et al. 2008). In the United States, the enforcement and monitoring of environmental regulations is conducted primarily by the government regulatory agencies. The other groups are able to contest regulatory decisions, but outcomes depend on the structured processes (Kuzma et al. 2008).

To perform the oversight responsibilities, the regulatory agencies need sufficient financial and human resources (Hassler 2011, GAO 2010). Underfunded agencies are restricted in the number of inspectors they can hire and number of inspections that can be conducted. As enforcement decreases, the likelihood of being caught noncompliant also declines. Therefore, industry has a higher incentive to be noncompliant when inspection probability is low (Hassler 2011).

In complex systems, adequate oversight also requires human expertise and advanced technology to provide accurate and informative information. Private industries require the same expertise and technology, but often have greater financial resources to allocate to them (GAO 2010). As such, experts tend to move from regulatory agencies into private industry when offered higher earnings. Private industries also have an economic incentive to acquire the most updated and advanced technologies to assist operations. Public agencies do not. When these resource asymmetries exist, public agencies are forced to rely on the information produced by private industry (GAO 2010). Since industry studies have a possible conflict of interest, it erodes the oversight capabilities of the regulatory agency.

The 'revolving door' concept is used to describe the movement of technical experts from public agencies to private industries within the same system (Meghani and Kuzma 2010). Besides resource asymmetries, another concern with this movement is establishment of inappropriate relationships between the regulatory agencies and the associated industry (GAO 2010). Regulatory capture can occur when the close relationship between an industry and it regulatory agencies creates a conflict of interest that deteriorates environmental monitoring and enforcement. There are many examples of regulatory capture contributing to risk events in the United States. A recent example is the oil industry capture of the Mineral Management Services (MMS) and the resulting Deepwater Horizon Oil Spill in the Gulf of Mexico (GAO 2010).

Technological risk management can be even more difficult because long time intervals between incidents often induce complacency (Freudenburg 1992). When risk incidents do not occur during a period of the time, the system is often perceived with less risk (Slovic 1987). The atrophy of vigilance hypothesis suggests that, "when a hazardous system operates safely, responsible organizations will gradually reduce safeguards" (Freudenburg 1992). Managers may remove redundant safeguards and allow risky work behavior. Government agencies may reallocate funds and personnel to programs that have more immediate results. The 'atrophy of vigilance' is expected to reappear within a decade following a disaster incident (Busenberg 1999a). The public pressure can motivate risk vigilance, but is less effective when risks do not materialize or are not publically disclosed.

3. Human Errors

Risk management requires both technological and human capital to prevent and mitigate risks (Hassler 2011, Grabowski et al. 2009, Merrick et al. 2005). Accidents can occur when any necessary safeguard breaks down and initiates cascading events that result in harm (Grabowski et al. 2009). They are a culmination of interconnected events that can be prevented at different points within the chain. The more complex and interconnected the risk management system, the more vulnerable it is to organizational, managerial, and individual human error. Even though risk management technology has improved, accidents still occur because human decisions affect implementation (Hassler 2011). In complex systems, major failures are usually traced back to human errors as the root or intermediate cause (Grabowski et al. 2009). For example, human errors account for at least 80% of reported oil spills, but are not criteria considered within traditional risk assessments (Merrick et al. 2000).

Complex systems require coordination of simultaneous actions and decisions to maintain proper risk management within an organization (Merrick et al. 2005). The organizational, managerial, and/or individual components influence the direct actions and decisions that initiate and amplify risk events within a system. Human errors imply that the necessary knowledge, skills, and or abilities to perform a task were either not learned or not implemented. The worker quality, training process, safety promotion, open communication, feedback opportunities, and individual motivation all influence individual actions and decisions (Merrick et al. 2005).

In summary, risk management is challenging because it attempts to predict and respond to environmental risks in the future. Traditionally, it relies on information from quantitative risk assessments to make decisions. While this information is useful, it is not comprehensive because pertinent contributing factors related to risk management are not considered (Grabowski, et al. 2009). Risk management includes many risk drivers that can amplify the likelihood and severity of a risk event. Inadequate policy incentives, oversight capacity, and organizational systems can increase the vulnerability of the risk system.

D. A New Risk Paradigm

A new risk paradigm recognizes the limitations of traditional risk assessment and risk management approaches. To reconcile the limitations, public participation is often used to develop a broader systems perspective and integrate important social values (Ansell and Gash 2007). The rationale for public participation includes instrumental, legitimacy, and normative arguments that are summarized and described below.

Public participation has many definitions, designs, and purposes that make consistent interpretation difficult. For this paper, public participation is defined as "a process where individuals, groups, and organizations choose to take an active role in making decisions that affect them" (Reed 2008). In this way, public participation is specific to the stakeholders, individuals or organizations with the direct possibility of benefit or harm.

However, the literature does not always clarify how the term 'public participation' is used for various analyses. Therefore, the following review of public participation includes arguments for the inclusion of stakeholders *and* individuals from the general public. Individuals from the general public may not have a have direct possibility of harm, but nonetheless have an interest or value in a particular issue. Klinke and Renn (2002) developed a risk management escalator that outlines when broader participatory approaches are necessary for various risk categories. The following literature review does not differentiate among public participation typologies. Instead, it identifies the main arguments in favor of broader public participation in a general sense.

1. Instrumental Perspective

As discussed, risk decisions require both knowledge and values to maintain relevancy and reduce uncertainty (Reed 2008, Renn et al. 2009). The instrumental perspective envisions public participation as a means to this specific end goal (Reed 2008). Public participation is valued as an important mechanism that can improve risk governance by expanding the available knowledge, integrating socials values, and motivating risk vigilance.

For complex issues, risk assessment and risk management can benefit from broader system perspectives. Therefore, all stakeholders, including the public, are valuable because they have unique information to contribute. The public represents social values, but can also contribute information from a variety of other professional fields that can help inform ongoing decisions (De Marchi 2003). Since most professions require some degree of technical knowledge, it is erroneous and limiting to assume that the public is scientifically illiterate (De Marchi 2003). Deliberation among broad areas of expertise can develop creative new risk management options and work towards win-win solutions (Renn and Schweizer 2009). Even contestation can help clarify the problem and select options that best meets social values and scientific knowledge (De Marchi 2003).

The public also has local expertise regarding regional values and conditions that can be important to risk assessments and management. Regional values are important during problem formulation, situations of irreducible uncertainty, and interpretation of acceptable risk (Byrd et al. 2000). During problem formulation, public participation is useful to ensure that the risk assessment has social relevance.

Public participation can also be used to deal with uncertainty obstacles and interpretation of acceptable risk (Klinke et al. 2002). Local knowledge can be used to identify risk hazards, sources, and stressors that are important modeling components, but undetected by scientists. Broader deliberation is also useful when uncertainty cannot be reduced because values are necessary to determine whether the residual uncertainty and risk is socially acceptable (Aven et al. 2009). While traditional risk assessments historically focus on probability and extent of damage, society is often concerned about other risk characteristics, such as uncertainty, ubiquity, persistency, reversibility, detection lag time, equity, psychological stress, and spillover effects (Klinke et al. 2002, Slovic 1987). Public deliberation can address and prioritize these broader risk characteristics to determine acceptable risk. In general, public participation can help produce more comprehensive, relevant and higher quality information than would otherwise occur (Reed 2008).

Public participation can also play an important role in maintaining risk vigilance. Particularly in risk systems that involve innovative technology, public participation can provide highly responsive feedback that can enhance adaptive capacity (Reed 2008). Public oversight organizations have a personal incentive to maintain a risk vigilant system and hold other stakeholders accountable (PWSRCAC 2011). It can disrupt or prevent temporally induced complacency and inappropriate relationships between industry and regulatory agencies from taking hold (Busenberg 1999a).

2. Legitimacy Perspective

Another reason to incorporate public participation is that it adds legitimacy to scientific risk assessments and risk management decisions (Renn and Schweizer 2009). Allowing public access to the process creates transparency that can hold the government, industry, and scientists accountable to the public interest (Steiner 2007, Reed 2008). Transparency implies that the 'public has access to information about the other main stakeholders involved in risk decisions and has a clear understanding of what they are doing' (Steiner 2007). Active participation unveils value judgments throughout the process and forces intermediate decisions to pass public scrutiny. As a result, the final product is more likely to have widespread support upon completion.

Additionally, long-term, direct interactions among opposing positions can provide an opportunity for mutual learning about the problem, interests, and positions involved (Renn and Schweizer 2009). It can transform adversarial relationships and increase trust among the various stakeholder groups (Rowe and Frewer 2000, Steiner 2007). Public trust is necessary because widespread protests can delay projects, discredit scientific assessments, and devastate reputations (Wu and Farland 2007).

3. Normative Perspective

The normative rationale for public participation views the traditional risk paradigm as being incompatible with democratic principles of equity, fairness, and citizenship (Fiorino 1990; Kuzma and Besley 2008; Reed 2008). Many perceive public participation as a democratic human right and a crucial component of procedural justice that helps maintain a functional democratic society (Reed 2008, Rowe and Frewer 2000). The normative view accepts that the public is the best judge of their own interests when provided all the relevant information (Fiorino 1990).

From an ethical standpoint, the people most at risk should have the opportunity to influence the management decisions that will affect them (Klinke and Renn 2002). Public opinion and elections do not provide direct voice into specific risk decisions. Furthermore, the communities at risk are usually less organized, experienced, and funded than the opposing interests (Rich et al. 1995). Public participation is a mechanism that can balance the playing field among the affected stakeholders.

In addition, public participation opportunities can increase community capacity and civic agency (Rich et al. 1995). The political process has a learning curve that can intimidate individuals from getting involved in the process independently. Structured opportunities for public participation can teach the political process and signal that all viewpoints are useful. It can instill confident civic agency and empower communities to be more actively involved in ongoing policy decisions (Rich et al. 1995).

4. Current Participation Approaches

Public participation is already recognized as an important component of environmental decision making. In 1996, The National Resource Council concluded that public participation, "is critical to ensure that all relevant information is included, that it is synthesized in a way that addresses parties' concerns, and that those who may be affected by a risk decision *are sufficiently well informed and involved to participate meaningfully* in the decision ."[1]

With growing recognition, government agencies are now required to incorporate 'public participation' into environmental planning and policy processes. For example, most environmental laws require a public notice and comment period (EPA 2002). Public hearings are also a common requirement of certain provisions. Some environmental laws (SDWA, CAA, RCAC, CERCLA) even have provisions that require more involved public participation, such as citizen advisory groups (EPA 2002). In general however, traditional public participation approaches are often criticized for lacking two-way interaction and decision-making influence (Abelson et al. 2003).

In response, many risk managers are designing new approaches that go beyond the traditional participatory requirements. Greater public involvement has become one strategy to better deal with complex and uncertain risks (Reed 2008). For example, the Environmental Protection Agency (EPA) uses a risk analysis framework that integrates the traditional assessment and management components during two critical phases of an ecological risk assessment (EPA 1998). It focuses on deliberation during the initial planning phases when the problem definition and management goals are constructed and communication when the analysis is presented to other participants. In similar fashion, The National Research Council (NRC) has recently published a new report, coined The Silver Book, to improve risk assessment by integrating broader perspectives during problem definition and risk acceptance phases (NRC 2009). However, neither framework specifies the public participation process that should be implemented.

The environmental field has been one leader in designing actual participation approaches to improve the management of complex systems with high uncertainty. Adaptive management and collaborative environmental management are widely acknowledged approaches that have been implemented for a variety of natural resources including water, forestry, and endangered species (Koontz 2006). Adaptive

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[1] NRC (1996) report does not focus on general public engagement and education, although members of the public who are interested and affected would be included.

management deals with uncertainty by creating environmental experiments that select a strategy, closely monitor effects, and adjust action based on monitoring results (Linkov et al. 2006). Linkov et al. (2006) suggest public participation is an essential component of adaptive management because it enhances monitoring feedback and develops mutual trust.

Compared to adaptive management, collaborative environmental management (CEM) is even more focused on public participation as an implementation strategy. Koontz (2006) describes it as, “the process of engaging citizens, along with government officials and other interested stakeholders, in all phases of the policy process.” One expectation of CEM is that uncertainty will be better managed by leveraging joint research and fact-finding among stakeholders (Wondolleck and Yaffee 2000). Additionally, diverse perspectives directed into constructive deliberative can create a shared vision and resolve conflict.

Highly participatory efforts move towards a new risk governance paradigm, but are still the exception to the rule. Linkov (2006) concludes that adoption and use of adaptive management is lagging far behind government recognition and recommendation. One main reason for the limited adoption is the challenges associated with the evaluation of participation processes. For example, Linkov (2006) noted that adaptive management is often implemented using widely different techniques. Since concept implementation varies across context, government agencies and other practitioners continue to struggle what makes “good” participation (Santos and Chess 2003).

There has been extensive research describing how design components, such as representation and interaction, affect the outcomes of public participation methods (Rowe and Frewer 2000, Reed 2008, Fiorino 1990). Reed (2008) recognizes that many important process components are easier to achieve when participation is institutionalized. Reed (2008) acknowledges the limited success of many participatory efforts when he says,

> “Although participation is increasingly becoming embedded in policy, the requirements of participatory processes are at variance with many of the institutional structures of the organizations charged with implementing these policies. Many of the limitation experienced in participatory processes have their roots in the organizational cultures of those who sponsor or participate in them.”

Creating new governance institutions for public participation would demand significant governance shifts (Reed 2008). Ansell and Gash (2007) claim that these governance shifts are usually initiated by previous government failures. However, even disasters that act as focusing events cannot guarantee that governance shifts will occur (Kurtz 2004). Other development components are often needed. Institutionalizing public participation is assumed to be extremely challenging, if not altogether impossible (Reed 2008).

Moreover, it is acknowledged that institutionalized public participation is not necessary for all risk contexts. Not all environmental risks warrant an elaborate participation process; the approach needs to match the situation (Abelson, et al. 2003, Rowe and Frewer 2005, Klinke and Renn 2002). As mentioned, Klinke and Renn (2002) propose increasing participation as risks move from simple, to complex, uncertain, and/or ambiguous. However, these three risk characteristics are often interrelated, which makes the participation assignment less clear than it suggests. No scheme can directly prescribe a successful participation method for every context. However, general contextual factors may indicate the scope of involvement required.

Recent research has started to acknowledge the multiple frameworks that interact to affect risk governance success (Santos and Chess 2003, Kuzma et al. 2008, Koontz 2006). For example, Koontz (2006) developed an institutional analysis and development framework to 'illuminate government-stakeholder relationships and the interplay of biophysical and social factors'. The framework examines how government actors, governmental institutions, issue definition, resources for collaboration, and decision process interrelate to affect risk outcomes (Koontz 2006). In addition, Kuzma et al. (2008) created an integrated approach to oversight assessment by nesting critical components into four broader categories, including: development, attributes, evolution, and outcome. These approaches illustrate how single metrics cannot provide a comprehensive assessment.

Complex technological and environmental risks continue to demand a new management approach that can systematically handle uncertainty and value conflicts (Faucheux and Froger 1995, Aven and Renn 2009, International Risk Governance Council 2011). Broader participation has been deemed an important strategy in moving towards a new risk paradigm. However, successful risk outcomes are impacted by numerous interrelated variables specific to process design, development capacity, and risk context. It is unclear what combinations of factors warrant elaborate integration of public participation. Moreover, the actual benefits from institutionalizing public participation remain ambiguous. Without understanding the potential benefits, it is difficult to justify such a large governance shift. The purpose of this analysis is to examine a risk governance system that has already shifted towards the new risk paradigm and highlight important implications for other complex and uncertain environments.

I. Paper Purpose

This paper examines a technological-environmental risk system that has already shifted towards a new risk governance paradigm. The risk governance system surrounding the Alaskan oil terminals and tanker transportation has institutionalized two independent citizen advisory councils. The Prince William Regional Citizen Advisory Council (PWRCAC) and Cook Inlet Regional Citizen Advisory Council (CIRCAC) were established in response to the Exxon Valdez Oil Spill (EVOS) to ensure adequate oversight of terminal and tanker activities. The Oil Pollution Act 1990 intended for the RCACs to be a pilot program that would eventually extend into other crude oil terminals throughout the United States (Ginsburg, Sterling and Gotteherer 1993). At present, however, citizen advisory councils with a similar model have not been replicated at other U.S. terminals.

The Alaskan RCACs have a significant role within the risk governance system that goes beyond third-party oversight. The RCACs are influential stakeholders in risk assessments, risk management decisions, and ongoing risk vigilance. With the creation of the Alaskan RCACs, the risk governance system has become a model for a new risk paradigm. The multi-framework systematically analyzes the PWSRCAC risk context, development, process, and outcomes. The study acknowledges that no management strategy or governance arrangement will be optimal in all situations, but intends to highlight significant features that could be tailored to improve other risk systems.

II. Methodology

A. Overview

This paper uses a case study analysis approach to identify the major factors in the context, development, and design frameworks that have contributed to risk outcomes in the Alaskan oil terminal and tanker system. Criteria from the research literature are used to guide each framework analysis. The risk context and outcome frameworks are the main focus. They use the same structured multi-criteria analysis to examine how risk factors have changed since the new risk governance system has been formed. Since the development and design frameworks greatly influence risk outcomes, these frameworks are also analyzed. However, the development and design analysis is less structured and criteria from the literature are only used as a guide; other important factors that emerge are also identified. Criteria are defined as the pre-established components that guide analysis. Critical factors are defined as the most influential components of each framework that affect risk outcomes.

Each framework analysis includes a detailed description and summary of critical factors that have affected risk outcomes. Content analysis is used to search for major themes related to the identified criteria and risk governance outcomes. The critical context, development, and design factors are not weighted or prioritized; they are only identified. However, the risk outcome factors are given a descriptive weight, including: significant decline, decline, no change, improvement, or significant improvement. The assignment of descriptive weight is based on how the PWSRCAC has specifically affected the risk outcomes in the governance system.

B. Scope

A case study of the marine oil transport system in Alaska is used to provide a retrospective analysis of a new approach to risk governance in complex and uncertain environments. Two Regional Citizen Advisory Councils (RCACs) have been established to advise and supervise risk management of oil terminal and tanker activities in Prince William Sound and Cook Inlet, AK. These citizen organizations are permanent arrangements that ensure that knowledgeable citizen voice is incorporated into risk governance issues related to oil terminal and tanker activities. While the RCAC role is completely advisory, both RCACs have been able to leverage their financial and human resources to implement risk policy and ensure management vigilance (Busenberg 2007).

Prince William Sound Regional Citizens' Advisory Council (PWSRCAC) and Cook Inlet Regional Citizens' Advisory Council (CIRCAC) are both structured by the Oil Pollution Act of 1990 and industry contract. Thus, they have virtually identical function, design, and responsibilities. However, the current analysis limits the scope to the PWSRCAC because it is responsible for the area most affected by the Exxon Valdez Oil Spill (EVOS) and has a more prominent role in regional policy implementation (Busenberg 2007).

C. Sources

The PWSRCAC case study was conducted using document analysis from three main sources. First, government investigation reports in response to the Exxon Valdez Oil Spill (EVOS) were used to describe the focusing event and subsequent policy changes. Second, the PWSRCAC website provides access to all jurisdiction documents and publications. These were used for all sections of the analysis, but especially the design evaluation framework. Finally, a Google Scholar search was conducted to find relevant academic literature related to the Alaska Regional Citizen Advisory Councils.

Numerous sources contributed to the creation of the multi-framework analysis. After the first Google Search was conducted to find case study evaluation criteria, multiple criteria categories became evident. Based on the general search, four criteria categories were created: risk context, development, design, and outcomes. Each of these categories appeared to be interrelated and important to outcome evaluation. The multiple framework approach was later validated by other multi-criteria analyses found in the literature (Kuzma et al. 2008, Koontz 2006).

D. Framework Construction

While every complex risk context requires a uniquely designed management strategy, the Alaskan RCACs could be a useful model to be tailored for other governance systems that manage complex or emerging risks. This paper develops and uses a multi-framework systems analysis that examines four main components of the case study: context, development, design, and outcomes (Figure 1). These four categories were created from the evaluation criteria in the literature. The categories align closely with the Integrated Oversight Assessment (IOA) developed by Kuzma et al. (2008).

The four analysis frameworks include interrelated factors that increase and decrease the likelihood of successful outcomes (Figure 1). However, each asks inherently different questions:

Context Framework: When is the RCAC model for risk governance *necessary* or *appropriate*? Under what conditions?

Development Framework: What social and political factors are needed to make the elaborate shift to a new risk governance paradigm *feasible*?

Design Framework: How should the new *structure* and *process* of the public participation institutions be designed?

Outcome Framework: How has the risk context changed since PWSRCAC establishment?

The current analysis focuses on the risk context and outcome frameworks to highlight the conditional factors that warrant a new risk paradigm shift. The development and design frameworks are acknowledged to be equally important and intricately interrelated. Therefore, these frameworks are also examined using evaluation criteria from the literature as a guide. The development and design factors most important to the new risk governance outcomes are indicated with bold italics throughout the final outcome analysis. The guiding criteria for development, design, risk context, and outcome frameworks are discussed further in the subsequent sections and outlined in Figure 2. The analysis of each framework uses the pre-established criteria and content analysis to indentify the critical factors that have affected risk outcomes. Criteria are used to structure or guide analysis. Critical factors are defined as the framework components that are particularly influential to risk outcomes. They may be the pre-established criteria or other critical components that emerge from the analysis.

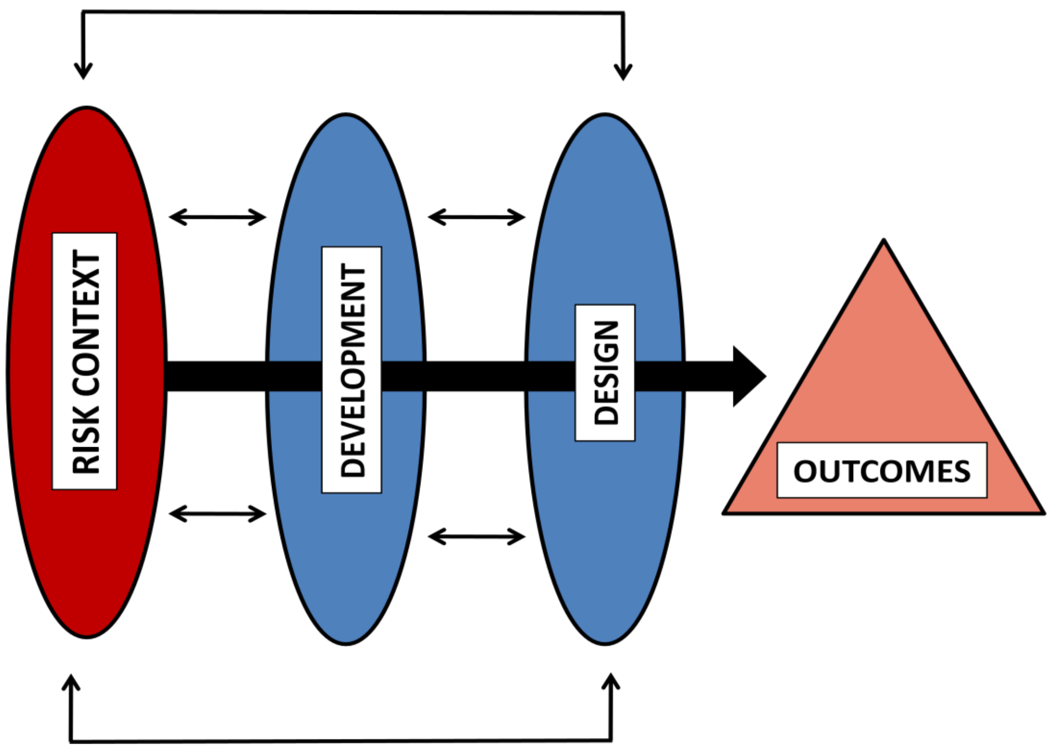


Figure 1. Multi-Framework Analysis Diagram. The outcomes of a new risk governance shift are influenced by the risk context, development capacity, and participatory design. The criteria within each framework overlap and interrelate. An adaptive framework analysis would examine how outcomes provide feedback that affects each of the other frameworks. However, the current analysis is only concerned with how risk context, development, and design have influenced current risk outcomes in the system. Traditional influence diagram shapes are used to differentiate the contributing frameworks (ovals) and consequential outcomes (triangle). Color denotes the type of analysis used for each framework. Risk Context/Outcomes = Red/Light Red = Structured Multi-Criteria Analysis using the IRGC risk factors for criteria. Development and Design = Blue = Guiding Criteria from the literature review.

1. Development

The development framework analysis explores the factors that made the risk governance shift feasible in PWS. First, the Exxon Valdez Oil Spill (EVOS) focusing event and the PWSRCAC policy creation are described in detail. Guiding evaluation criteria from the literature are used to identify the most important contributing factors. These evaluation criteria are only used as a guide; other important factors specific to the PWSRCAC case study are also identified.

A great deal of research has been conducted on the developmental factors that are needed to initiate and create a more collaborative public participation process. Sociopolitical factors are particularly important determinants of whether or not a particular participation process is capable of becoming institutionalized.

Lawrence (2002) examines the 'enabling conditions' for corporate-stakeholder engagement by analyzing a case study involving the corporate oil company, Royal Dutch/Shell, and two human rights organizations. It concluded that the enabling factors for corporate-stakeholder engagement include mutual motivation, individual goals that require participation of the other party, organizational capacity to act, cultural affinity, recognized legitimacy, dedication to building trust and incremental gains (Lawrence 2002).

Ansell (2008) suggests that prior history among stakeholders, incentives, power and resource imbalances, leadership, and institutional design all determine whether collaborative governance is successful. Kuzma et al. (2008) recognize many important development factors such as: impetus, clarity of subject matter, legal grounding, public input, transparency, financial resources, and empirical basis. All of these factors are used as guiding criteria throughout the current development analysis. Many of criteria overlap with the design and context criteria, illustrating the intricate overlap and interaction among analysis frameworks. Since these factors directly influence the outcomes, they are identified in bold italics throughout the outcome framework analysis.

2. Design

The design framework analysis explores the critical factors about the PWSRCAC structure and process that contribute to successful outcomes. First, the PWSRCAC organizational structure and processes are described in detail. Then, guiding evaluation criteria from the literature are used to identify the most important contributing factors. These evaluation criteria are only used as a guide; other important factors specific to the PWSRCAC case study are also identified.

The structural and process components that contribute to successful participation have been extensively studied. Rowe and Frewer (2004) reviewed the literature and identified the evaluation criteria most commonly cited as important considerations. The criteria that overlapped with the literature review conducted in this paper include representation, fairness, flexibility, early involvement/continuous involvement, transparency, resource accessibility, independence, interaction, continuity, competence, and deliberation. Reed (2008) recognizes the additional importance of highly skilled facilitation and institutionally embedding participation. Many of these design criteria overlap with the development and context criteria, illustrating the intricate overlap and interaction among analysis frameworks. Since these factors directly influence the outcomes, they are identified in bold italics throughout the outcome framework analysis.

3. Risk Context and Outcomes

This case study evaluates the Prince William Sound Regional Citizens' Advisory Council (PWSRCAC) within the risk governance structure of the marine oil transportation system in Alaska and assesses the potential application of similar public participation institutions within other similar systems. Since marine oil transportation has been characterized as a system with immeasurable risk pathways that have the potential to result in a risk event, the whole system can be characterized as a complex risk. Therefore, this analysis uses the risk factors identified in the International Risk Governance Council (2010) report, *The Emergence of Risks: Contributing Factors* as the analysis criteria to evaluate the risk context before and after the PWSRCAC creation.

The risk context framework analysis examines the IRGC risk factors before the EVOS. Then, the outcome framework analysis describes how each IRGC risk factor changed once PWSRCAC became a prominent stakeholder in the risk governance system. The critical development and design factors are indicated with bold italics throughout the outcome framework analysis. As such, the outcome framework analysis illustrates how the critical factors of each framework contributed to outcomes identified.

The risk factors identified in the IRGC Report (2010) are not intended to be discrete units, but interdependent factors that can heighten the system vulnerability to risks (International Risk Governance Council 2010). Collectively, these multiple risk factors make a 'fertile ground' from which risks can emerge. Each component is necessary, but individually is insufficient to produce a risk outcome. Instead, the interaction of these 12 factors in different combinations and pathways heighten the likelihood and severity of potential outcome. Based on the IRGC publication, an expanded and explicit description for each risk factor in the context of the PWSRCAC is provided below:

1. **Scientific Unknowns:** Reliable science is often in short supply when management decisions are necessary. Unknowns can either be tractable or intractable, but both can contribute to unanticipated risks. *Evaluation centers on how much the PWSRCAC increases tractable unknown detection and*

reduction while simultaneously increases system resiliency to intractable unknowns.

2. **Loss of Safety Margins**: Complex, interdependent systems have tight coupling among components that can accelerate the spread of damage and initiate cascading effects. Safety margins compare the system stress and the system coping capacity. They buffer the system from potential interdependent effects. Decreasing the buffering capacity leaves the system more vulnerable to disruption and increases the likelihood of risks. *Evaluation assesses the influence PWSRCAC has on establishing firewalls to limit damage between components and build system redundancy to limit cascading effects.*

3. **Positive Feedback:** Some processes amplify or attenuate the likelihood or severity of risk. They can occur through natural or social processes and can be beneficial or detrimental. The current case study will consider positive feedback related to the system communication. *Positive feedback in this context is regarded as beneficial. PWSRCAC is evaluated by its ability to increase positive feedback within the risk governance system.*

4. **Varying Susceptibilities to Risk:** The consequences of risky activities do not usually affect all populations equally. Risk severity often differs based on geography, genetics, experiences, and income. Low income populations tend to be more susceptible and less likely to respond to potential risks. *Evaluation will center on PWSRCAC's ability to increase the response capability and decrease impacts on vulnerable populations.*

5. **Conflicts about Interests, Values, and Science:** This is a broad risk factor that encompasses contested science and incompatible values. In highly controversial situations, risk profiles are more difficult to determine because assessment assumptions are exposed by opposing sides to highlight biases and interest-driven science. As a result, trust deteriorates among stakeholders. *Evaluation will assess the changes in risk governance trust and consensus-seeking deliberation among stakeholders since the inception of the PWSRCAC.*

6. **Social Dynamics:** Also related to interdependencies in the system, social dynamics relate to the behavioral norms and psychology that can accentuate or attenuate the likelihood and severity of risks. *Evaluation focuses on how PWSRCAC has altered and sustained social dynamics that attenuate the likelihood and severity of oil spills.*

7. **Technological Advances:** Scientific investigations and regulatory frameworks are not always sufficient for appropriate risk management of technology, especially innovative technology without historical understanding. Regulation is the principle tool used to manage technological risks. However, regulatory agencies often lack leadership, expertise, and resources. *Evaluation will determine if the PWSRCAC has increased the flexibility, innovation, and urgency in the regulation of technological risk.*

8. **Temporal Conditions:** Some risks are difficult to anticipate and detect because of inherent or surrounding system complexity. Warning signs that have lag times increase the likelihood that a risk can occur undetected. Similarly, delayed response increase the severity of the risk. *PWSRCAC is evaluated based on its influence on the speed of system risk detection and response.*

9. **Communication:** Untimely, incomplete, or misleading communication can amplify risk. In contrast open communication can build trust, gather critical information, and lead to between anticipation of risks. PWSRCAC is evaluated based on its ability to increase the amount of two-way communication internally among the different risk management organizations and externally with the public. *For this context, this risk factor is essentially the same as positive feedback and will be combined.*

10. **Information Asymmetries:** When some stakeholders hold critical information about a risk that is not available to others it can erode industry reputation and public trust. It is also more difficult to hold responsible stakeholders accountable if the socially optimal risk management is unknown. *PWSRCAC is evaluated based on its ability to create partnerships and increase the level of information sharing.*

11. ***Perverse Incentives:** These are activities that either encourage risk-prone behavior or discourage risk prevention efforts. Such incentives relate to any activity that over values short-term gain and materializes when a misalignment exists between incentives industry faces and the amount of risk society desires. PWSRCAC mainly influences this risk factor by encouraging risk prevention efforts.

12. ***Malicious Motives and Acts:** These risk factors are most influential in widely distributed and interconnected systems, such as transportation networks. It includes deliberate attacks from terrorists, warring states, or other groups. While the Alaskan oil industry involves a widespread transportation system, this risk factor was not evaluated in this case study to limit scope to non-terrorist induced risks.

*Not evaluated in this case study (See reasons below)

The IRGC report acknowledges that not all of the contributing risk factors will be pertinent to every risk context (International Risk Governance Council 2010). In this study, to reduce scope, perverse incentives and malicious motives and acts are not considered. The perverse incentives risk factor is applicable to risk governance issues highlighted after the EVOS, but was specifically countered by increased liability and the industry trust fund established in OPA 90, not necessarily through PWSRCAC. PWSRCAC may alter the market incentives, but it likely does it indirectly through alterations to other risk factors being evaluated. Malicious motives and acts are not considered an important risk factor within the Alaskan marine oil transport system because attacks have not occurred in the past. Since positive feedback and communication are combined, only nine IRGC risk factors are used in the retrospective analysis of the Alaskan RCAC to evaluate context and outcomes on the risk governance system. Figure 2 summarizes the framework and the guiding criteria used in this paper.

Framework	Guiding Questions	Guiding Criteria
Risk Context	When is the RCAC model for risk governance necessary or appropriate? Under what conditions?	Scientific Unknowns, Loss of Safety Margins, Positive Feedback/Communication, Varying Susceptibilities to Risk, Conflicts about Interests/Values/Science, Social Dynamics, Technological Advances, Temporal Conditions, Information Asymmetries (IRGC 2010)
Development	What social and political factors are needed to make the elaborate shift to a new risk governance paradigm feasible?	Mutual Motivation, Dependency, Organizational Capacity, Cultural Affinity, Recognized Legitimacy, Dedicated to Trust Building and Incremental Gains (Lawerence 2002); Ansell (2008) Prior Stakeholder History, Incentives, Power and Resource Imbalances, Leadership, and Institutional design (Ansell 2008); Impetus, Clarity of Subject Matter, Legal Grounding, Public Input, Transparency, Transparency, Financial Resources, Empirical Basis (Kuzma 2008)
Design	How should the new public participation institutions be designed (process, structure, resources)?	Representation, Fairness, Flexibility, Early Involvement/Continuous Involvement, Transparency, Resource Accessibility, Independence, Interaction, Continuity, Competence, and Deliberation (Rowe and Frewer 2004); Participatory Philosophy, Early/Continuous Involvement, Representation, Clear Objectives, Tailored Methods, Facilitation, Integrated Scientific and Local Knowledge, Institutionalized (Reed 2008)
Outcomes	How has the risk context changed since PWSRCAC establishment?	Scientific Unknowns, Loss of Safety Margins, Positive Feedback/Communication, Varying Susceptibilities to Risk, Conflicts about Interests/Values/Science, Social Dynamics, Technological Advances, Temporal Conditions, Information Asymmetries (IRGC 2010)

Figure 2. Multi-Framework Analysis Guiding Questions and Criteria Chart

III. Multi- Framework Analysis

The Alaskan oil transportation system is used as a case study to examine the three broad barriers of successful implementation of more participatory risk governance systems. A retrospective multi-framework analysis of a risk governance system already established is used to identify the potential outcomes and the contributing critical components. First, a descriptive analysis is conducted on the EVOS and PWSRCAC policy creation. Second, a descriptive analysis is conducted on the PWSRCAC organizational structure and processes. Finally, the IRGC (2010) risk factors are used in a structured analysis of the risk context and outcomes. Critical factors of each framework are identified after each step. The critical development and design factors are identified in bold italics throughout the outcome framework analysis to illustrate how those factors influence the outcomes and ultimately success.

A. Development Framework

The EVOS impetus and PWSRCAC creation is described in the following two sections. The critical development factors that emerge from both sections are identified and discussed afterwards. The evaluation criteria from the literature are used as a guide, but other important development factors influencing the PWSRCAC outcomes are identified. The critical factors are identified in bold italics throughout the outcome framework analysis.

1. Descriptive Analysis

Impetus: Exxon Valdez Oil Spill

On March 24th, 1989 a major oil spill in Alaska illustrated many risk governance failures related to risk prevention and response when the Exxon Valdez supertanker accidentally ran aground on Bligh Reef in Prince William Sound, AK (Figure 3). The captain had notified the U.S. Coast Guard Vessel Traffic Service (VTS) that the tanker was moving into the incoming traffic lane to avoid icebergs from the Columbia Glacier (The National Response Team 1989). However, the tanker was directed too far off course and eventually ran aground Bligh Reef in only 30 feet of water. By the time the response team arrived, 10 million gallons of oil had already escaped across the remote and sensitive landscape (The National Response Team 1989).

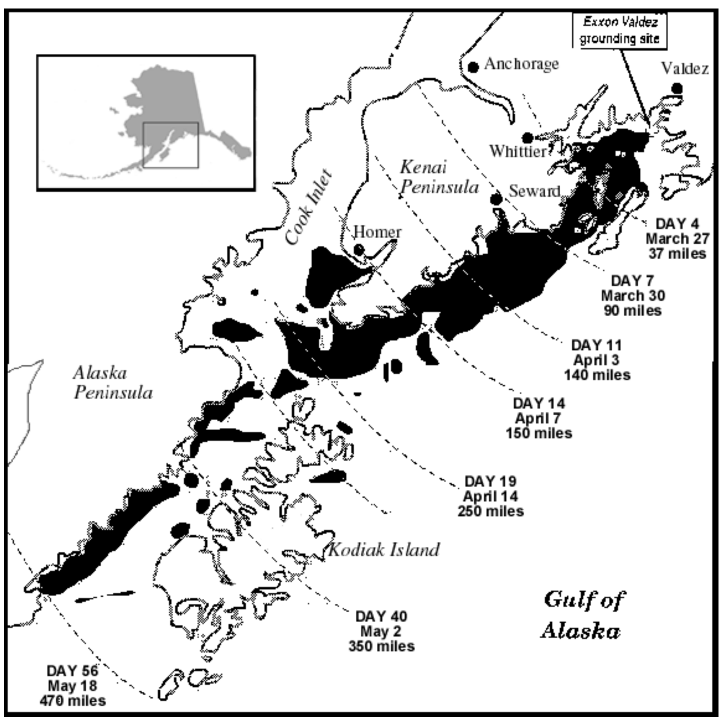
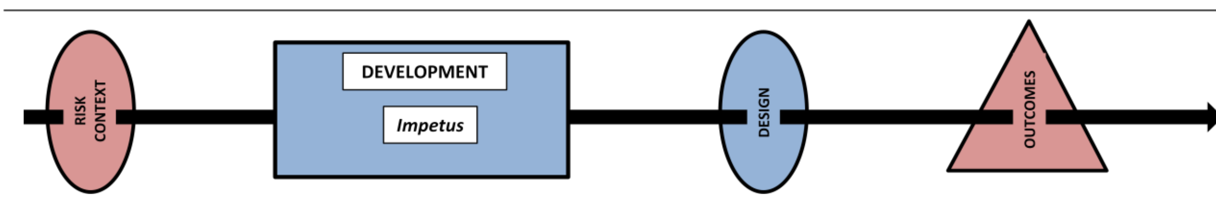


Figure 3. Exxon Valdez Oil Spill Map (EVOSTC 2012)

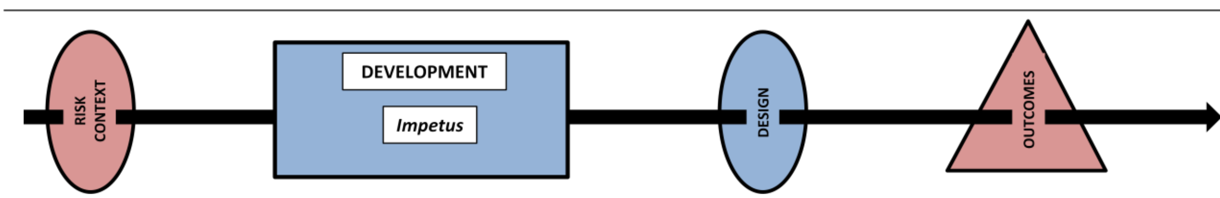


The subsequent response, coordinated by various federal, state, and industry organizations, was inadequate and only intensified the severity of the spill. The response was characterized by uncoordinated mitigation efforts, insufficient equipment, and delays (The National Response Team 1989). As illustrated in Figure 4, management decisions were complex and required knowledge that was not available or adequately coordinated among stakeholders (Harrald et al. 1990). For example, organizations involved had different oil spill contingency plans and none were prepared for large-scale implementation. The opportunity to burn surface oil passed as agencies struggled to reach protocol consensus (The National Response Team 1989). Over 14,000 vessels and 85 helicopters operated by various agencies and stakeholders were dispatched without any response training (The National Response Team 1989).

Technology used in the response included chemical dispersants, burning, biomediation, oil containment booms, oil skimmers, and pressure washes (National Parks Service 2009). However, these approaches were largely ineffective. Initial vessel response was delayed 10 hours because the emergency barge at the terminal was not ready for deployment (The National Response Team 1989). Additionally, local equipment supply was both insufficient and unexpectedly damaged. The one oil skimmer was only able to recover 32 barrels of oil before debris obstructions resulted in equipment failure (Alaska Sea Grant 1990).

The remote location of the spill and harsh weather exacerbated the technological inefficiencies (The National Response Team 1989). Containment equipment needed to travel long distances across often rough waters and radio communication suffered from intermittent connections because of the mountainous landscape. In the end, only about 10% of the crude oil was recovered from the spill (The National Response Team 1989).

At the time, the Exxon Valdez disaster was the largest and most expensive oil spill in North America. It established a new precedent to the magnitude of potential risks associated with marine oil trade. Exxon Mobile suffered a large financial loss to pay for damages (Costanza 2010). However, the community residents who were affected had the burden of proof of showing damages before receiving appropriate financial compensation. Most civil compensation was not awarded until nearly two decades after the



accident. Besides financial losses, the full costs of the accident also included environmental, health, and economic consequences that could not be directly recovered (Figure 5).

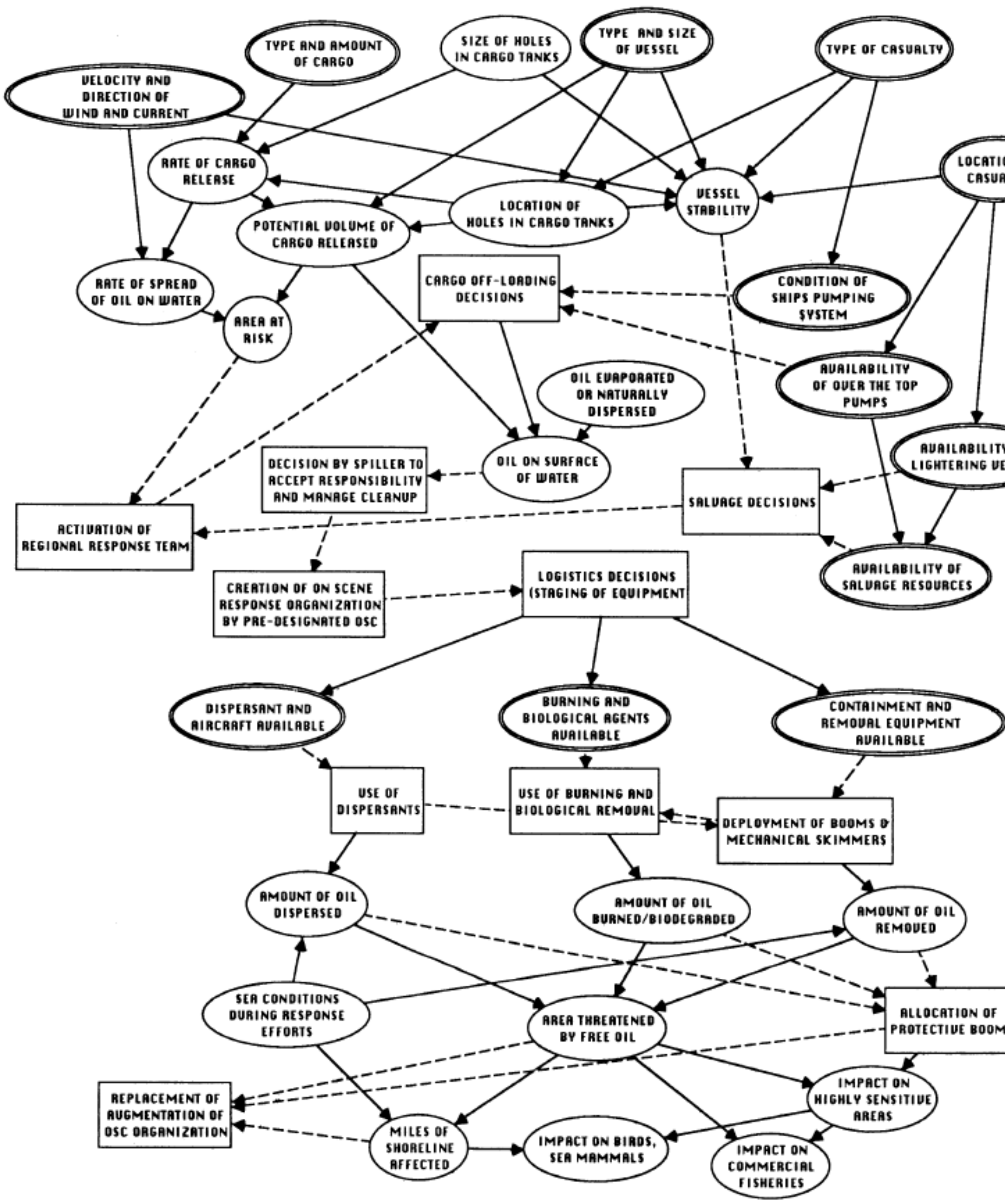
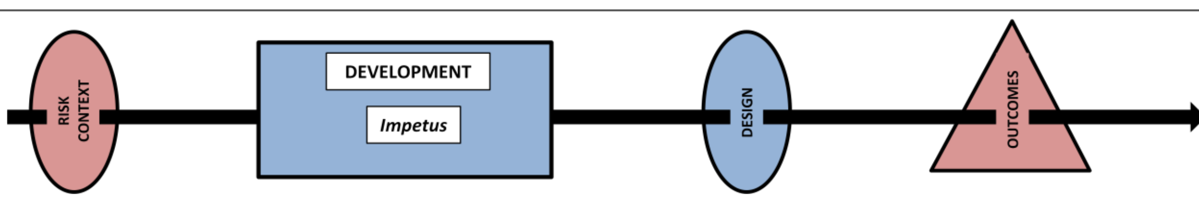


Figure 4. Influence Diagram of EVOS Response. Decisions are represented by rectangles and uncertain information is represented by ovals. (Harrald et. al 1990



Category	Damage
Exxon Mobile Financial	$150 million Criminal Plea Agreement, $100 million Criminal Restitution, $900 million Civil Settlement, $500 million punitive damages
Environmental	Nine marine mammal species(mortality = 20 seals, 20 sea lions, 1000+ sea otters, 25 grey whales*, 22 killer whales*), 71 species of seabirds (mortality = 270,000), decreased invertebrate populations, fish kills
Human Health	Native lifestyle disruption, worker hazards, depression, post-traumatic stress disorder, depression, alcohol/drug abuse, divorce
Economic	Fishery moratoriums, salmon fishery declines, herring fishery collapse, decreased tourism, decrease recreation
Other	Two decades of legal battles
	*unconfirmed

Figure 5. Costs of the Exxon Valdez Oil Spill

The environmental impacts spread across 1,300 miles of shoreline and impacted numerous wildlife species (National Parks Service 2009). The oil affected nine species of marine mammals, 71 species of seabirds, large invertebrate populations, and fisheries (National Parks Service 2009). Acute mortality affected at least 20 seals, 20 sea lions, over 1,000 sea otters, and up to 270,000 seabirds (Alaska Sea Grant 1990). An additional 22 killer whales disappeared in the following year (National Parks Service 2009).

The Alaskan commercial fishing industries included herring, salmon, pot shrimp, black cod, bottom fish, crab, and smelt (Alaska Sea Grant 1990). The timing of the spill coincided with the spring herring spawning. A temporary moratorium on some fisheries was initiated to protect future harvests and consumers from contamination risks. Nonetheless, the salmon fishery declined in 1990 and herring fishery collapsed in 1993 (Alaska Sea Grant 1990). The moratorium and lower harvests put economic strains on thousands of fisherman and the processing industry (The National Response Team 1989).

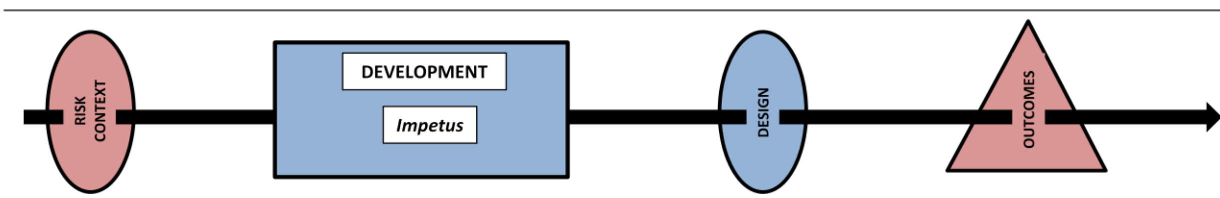
In addition, communities struggled to cope with numerous rising health ailments. Many commercial fishermen with privately owned boats were hired to assist with the clean-up. These workers had exposure to volatile components of crude oil and chemical dispersants (The National Response Team 1989). Other community health ailments included general anxiety, post-traumatic stress syndrome, and depression (Alaska Sea Grant 1990). Increased divorce rates and alcohol and drug use split up communities. Native communities were especially vulnerable to disrupting activity and warnings of seafood contamination (Alaska Sea Grant 1990).

The immediate oil spill causes involved a navigational error, possible captain intoxication, and crew fatigue (Alaska Sea Grant 1990). However, the investigation confirmed that the root causes were more systemic (Alaska Sea Grant 1990). The exact series of events that lead to the oil spill could not have been predicted. However, the management strategies failed to detect and firewall the chain of events that lead to the spill. The institutional arrangements that managed the technological risks had allowed a negligent atmosphere in which appropriate prevention and response safeguards were not in place. Complacency resulted from a lack of serious spills for several years, oil industry public relations, Coast Guard budget limitations, and regulatory capture evident by the interpersonal relationships among industry and government enforcement officials (Alaska Sea Grant 1989).

After the EVOS, the federal Oil Pollution Act of 1990 (OPA 90) and additional state legislation mandated more stringent safety firewalls. Some examples include the phase-in of double hulled oil tankers, deployment of vessel tracking systems with a larger range, more available response equipment, alcohol testing, and fewer worker hours (PWSRCAC 2009). They also established stricter liability provisions for an oil spill, a federal oil spill liability trust fund, and extensive institutional changes for risk management of terminal and tanker activities in Alaska (PWSRCAC 2009).

The state of Alaska established two new organizations in the risk governance system. The Exxon Valdez Oil Spill Trustee Council (EVOSTC) was created to oversee use of civil settlement funds with state and federal oversight. Also, the Prince William Sound Science Center was created to provide environmental monitoring and research.

Federal legislation established an additional three organizations in the system. The Prince William Sound Oil Spill Recovery Institute (OSRI) was created and funded from the federal trust to support research and development projects. In addition, Regional Citizens' Advisory Councils (RCACs) were mandated for Prince William Sound and Cook Inlet to provide direct stakeholder advice into marine oil transport



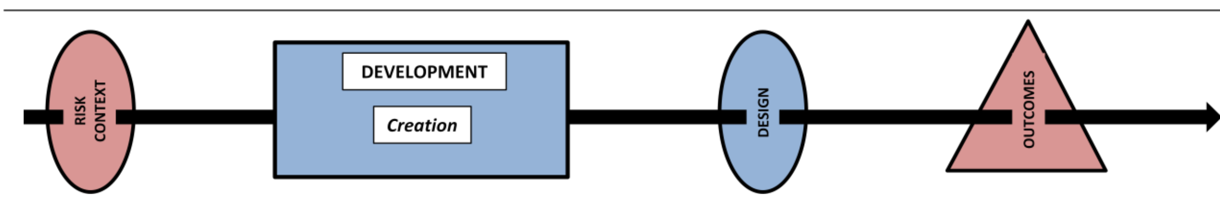
management. More stakeholder involvement was believed to combat the complacency that was perceived to be a major contributing factor to the Exxon Valdez accident.

The EVOS illuminated the high uncertainty surrounding the overlapping technological and environmental risks. The risk governance system had been unresponsive to warning signs and ignorant about the likelihood and severity of potential oil spills. Even though the risk was high, there was little incentive for industry or government agencies to perform additional risk assessments or implement new safeguards. Without actual damage, the main risk governance stakeholders were complacent. However, EVOS unveiled the risk and ignorance present in the system and triggered a highly reactive governance system. It primed the system for restructuring.

Creation

The public had attempted to create a Regional Citizens' Advisory Council (RCAC) prior to EVOS because they were concerned about the oil industry activities and regulatory oversight (PWSRCAC 2000, Ginsburg et al. 1993). The concept originated from an effective citizen council that manages the North Sea marine oil terminal in Sullom Voe, Scotland (Ginsburg et al. 1993, Steiner 2007). However, when the public group presented the concept to the Alyeska Pipeline Company, the oil industry had no political pressure to make such changes and declined the offer (Ginsburg et al. 1993). The concept eventually appeared in the Alaskan state legislature, but failed to pass amidst heavy lobbying by the oil industry (Steiner 2008).

The focusing event of the EVOS significantly changed the sociopolitical environment and primed the risk governance system for restructuring (Kurtz 2004). Escalating public suspicion, industry management changes, and political shifts helped create a new opportunity for RCAC development. In 1989, leaders from a highly motivated group of commercial fisherman in the city of Cordova invited the Alyeska Pipeline Company into a meeting to discuss the possibility of the PWSRCAC (Ginsburg et al. 1993). The Cordova group had previous experience organizing against the Trans-Alaska Pipeline, super tanker traffic, and periodic lawsuits (Alaska Sea Grant 1989). In the wake of the EVOS, Alyeska viewed a Regional Citizens' Advisory Council as a mutual gains opportunity and accepted the invitation to negotiate (Ginsburg et al. 1993).

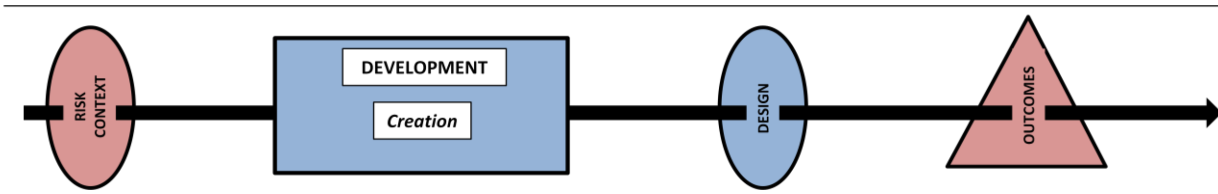


While Exxon Mobile was the only liable party, public backlash indiscriminately fell upon the entire industry. Since the Alyeska Pipeline Company is responsible for the oil industry pipeline and terminal, the company incurred a large amount of political criticism. The company strategized that a permanent partnership with a citizen group could improve public understanding of company prevention and response capabilities (Ginsburg et al. 1993). Additionally, the citizens had exhibited valuable local knowledge about the region and conditions during the response. The company wanted to incorporate this knowledge into the contingency plan improvements.

Stakeholders became more demanding having felt vindicated by the Exxon Valdez oil spill. The represented stakeholders were highly motivated to improve the risk management in order to protect their livelihoods (Ginsburg et al. 1993). While the region received an economic boost from oil industry activities, impacted stakeholders did not consider the management of the potential technological risks sufficient (Ginsburg et al. 1993). The potential risks disrupted the other important industries in the region, including commercial fishery and tourism.

In 1990, after six months of negotiations, the citizen group and the Alyeska Pipeline Company entered into a private contract with four critical conditions: annual funding, facilities access, organizational independence, and continuous longevity. In exchange, the citizen group would provide numerous services that would improve the risk management. These services included environmental monitoring, independent research, regional contingency planning advice, environmental protection, and public communication regarding Alyeska activities and capabilities (Ginsburg et al. 1993).

The inclusion of citizen oversight in OPA 90 was advocated and designed by many of the same leaders that negotiated the contract between the Alyeska Pipeline Company and the Alyeska Citizen's Advisory Council (Ginsburg et al. 1993). Therefore, the Alyeska Citizen's Advisory Committee already fulfilled the requirements outlined by OPA 90. In 1990, the Prince William Sound Regional Citizens' Advisory Council (PWSRCAC) and Cook Inlet Regional Citizens' Advisory Council (CIRCAC) were legitimized under federal law (Ginsburg et al. 1993). Both groups maintained the four contract agreements (funding, access, independence, longevity) originally established with Alyeska Pipeline Company.



2. Critical Development Factors

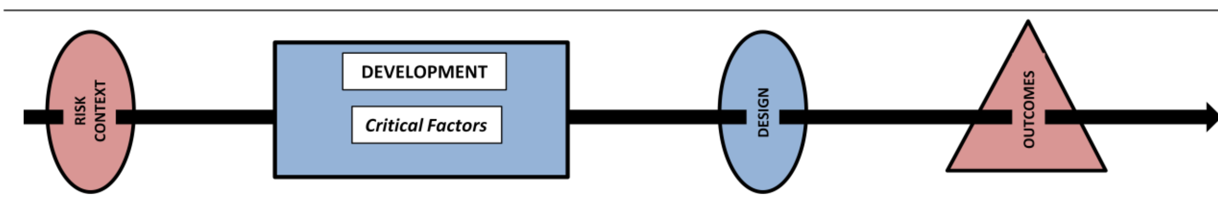
In summary, numerous social and political factors contributed to the development of the PWSRCAC. The EVOS was one of the most important factors in creating the opportunity for development. The EVOS acted as a focusing event that highlighted the risk governance failures. With the public trust completely deteriorated, there was an opportunity to renegotiate the social contract with government institutions and establish an industry-stakeholder partnership. The EVOS altered many of the sociopolitical factors described by Lawerence (2002) such as mutual motivation, interdependency, recognized legitimacy, and a new dedication to trust building. When these factors changed, so did the ***impetus*** for governance changes that incorporated greater public participation.

The EVOS incident created the opportunity for the PWSRCAC development; however, additional factors were also needed to push the concept through to implementation. First, there was an ***empirical basis*** from the citizen oversight group already in existence at the Sullom Voe, Scotland. It served as a model that validated the effectiveness of a more participatory risk governance system. Second, the financial ***resources*** were available from the oil industry and government grants to fund the organization. The annual costs are relatively low in comparison to the financial burden from an oil spill.

Other important factors of the PWSRCAC development include strong ***public leadership***, ***highly motivated stakeholders***, and ***policy familiarity***. Public leadership helped organize and sustain public pressure for policy change. Through a series of previous efforts, the public had become experienced and knowledgeable advocates for their interest. Burdened with a disproportionate amount of risks to benefits, they were highly motivated to safeguard their economic and social interests. Despite previous failures, the concept for PWSRCAC had become familiar to all main stakeholders in the system. It is likely that the familiarity with the policy alternative prior to EVOS aided its success afterwards.

B. Design Framework

The design framework analysis starts by describing the PWSRCAC organizational structure and process. Afterwards, the guiding evaluation criteria from the literature are used to identify the critical design factors that contribute to positive risk outcomes. However, other important design factors that appear



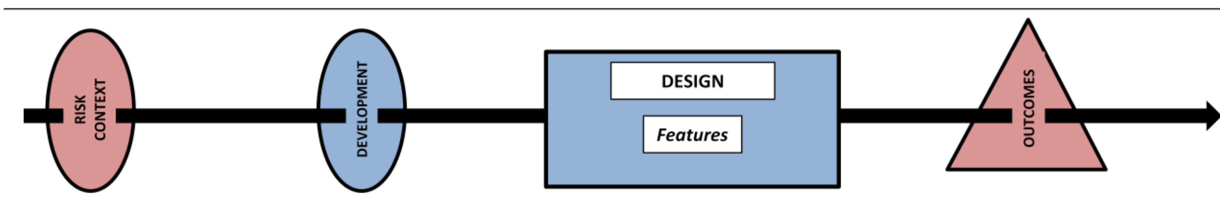
to affect the outcomes will also be identified. All critical factors are also identified in bold italics throughout the outcome framework analysis.

1. Descriptive Analysis

OPA 90 specifically states that the purpose of the Alaskan RCACs is to combat complacency and develop trust within the regulatory and oversight process (Ginsburg et al. 1993). Allowing a self-governing citizen group stronger voice into industry and government decisions was seen as a way of safeguarding the public interest (Steiner 2007). The organizational design, both its structure and process, ultimately affect its ability to achieve these end goals. As such, OPA 90 outlines specific design requirements that both Regional Citizens' Advisory Councils must meet, but allows an alternative design if it satisfies the intended goals. The Prince William Sound and Cook Inlet Regional Citizens' Advisory Councils both opted for an alternative design that reflects both OPA 90 requirements and industry contract components (PWSRCAC 2009).

Officially, PWSRCAC is an independent non-profit with a mission of organizing citizens to promote environmentally safe operation of the Alyseka Pipeline Service Company terminal in Valdez and oil tankers that use it (PWSRCAC 2011). Its structure and responsibilities stem from the Alyeska contract and OPA 90. As such, organizational goals include total compliance with both guiding documents, continue to improve environmental safety of oil transportation, develop and maintain excellent external and internal communication, and achieve organizational excellence (PWSRCAC 2009). The driving organizational values are volunteerism, providing effective voice for citizens, integrity through truth and objectivity, promoting vigilance, and combating complacency (PWSRCAC 2009).

The contract with the Alyeska Pipeline Company has four important requirements that are important to the PWSRCAC structure and processes. First, it guarantees annual industry funding that that starts at $2 million and is adjusted annually for inflation. Second, it provides access to all oil terminal facilities for routine inspections of the contingency response equipment. Third, it ensures absolute independence from the oil industry; thereby safeguarding the public interest. The fourth contract component certified that the agreement between the two organizations was valid as long as oil was transported within the region.



PWSRCAC has an entirely advisory role; none of their recommendations are legally binding. However, the group has been able to leverage its financial resources, human capital, and collaborative capacity to achieve successful implementation of many recommendations (Busenberg 2000). In addition, the PWSRCAC performs numerous activities that support ongoing recommendations. Some of these activities include, but are not limited to: (1) monitoring environmental health and industry facilities, (2) performing independent research, (3) reviewing policies, permits, and contingency plans, (4) advising new or reformed policies and contingency plans, and (5) communicating with the rest of the public (Ginsburg et al. 1993).

As mentioned, PWSRCAC relies on funding, quality personnel, and external partnerships to achieve its mission and conduct its necessary activities. In 2011, the budget totaled \$3.7 million, with \$3.2 million funded from the Alyeska Pipeline Service Company and the rest from government grants (PWSRCAC 2011). Sufficient funding allows the organization to independently gather pertinent and credible information from which to base recommendations. Knowledgeable people within the organization are also an important resource because it leads to higher quality recommendations, project initiatives, and external credibility (PWSRCAC 2009). In addition, partnerships with the public, industry, and government are vital to obtaining broad support for recommendations and alleviating the financial burden of large projects (Busenberg 2000, 1999b).

The organizational structure for both RCACs is a composite of voting stakeholders, non-voting government representatives, and industry funding (PWSRCAC 2011). The internal personnel consist of a board of directors, permanent staff, and committee groups. The PWSRCAC Board of Directors are appointed by specifically designated member organizations with representation from interests most at risk from marine oil terminal and tanker activities. Appropriated interests include commercial fishery, aquaculture, conservation, recreation, tourism, indigenous groups, and regional cities. Representatives are appointed for two-year terms, but are not restricted to any term limit. Involvement is completely voluntary; the PWSRCAC does not financially compensate board members or their organizations.

Currently, PWSRCAC has 19 board members with one member from each member organization; except the City of Valdez which has two seats. Member organizations include the Kodiak Island Borough, Chugach Alaska Corporation, Alaska State Chamber of Commerce, City of Kodiak, Community of

Chenega Bay, Cordova District Fisherman United, City of Seward, AK Wilderness Recreation and Tourism Association, City of Wittier, Kenai Peninsula Borough, City of Seldovia, Kodiak Village Mayors Association, Prince William Sound Aquaculture Corp., City of Valdez, the Oil Spill Region Environmental Coalition, Port Graham corporation, Community of Tatitlek, City of Cordova, City of Homer (PWSRCAC 2011).

Official board meetings occur three times a year and involve a comprehensive two-day review of project proposals, policy recommendations, financial decisions, and multi-interest stakeholder concerns (PWSRCAC 2012). Industry representatives and ex-officio government officials also attend to stay better informed about RCAC activities and risk issues. Board meetings are also a formal opportunities for industry to share information about operations and/or issues of concern. All meetings, including board meetings, are open to any public residents interested in gaining more information or making comments. To increase accessibility, board meetings are scheduled months in advance and rotate between the Valdez and Anchorage offices. All meetings are posted online with a toll free number that allows teleconference access to any interested individual or group unable to attend. The structure and process allows regular communication exchange among the public, industry, and government agencies.

The board of directors are further divided into four subcommittees, each responsible for specific organizational functions (PWSRCAC 2012). The Executive Subcommittee meets bi-weekly by teleconference and has decision-making authority in between official board meetings. The Board Governance Subcommittee is responsible for PWSRCAC by-laws and policies. The Legislative Subcommittee monitors developments in the state legislature, makes recommendations, and communicates with legislatures as directed by the BOD. The Finance Subcommittee directs all the ongoing financial decisions by meeting with independent auditors and staff members. The internal structure established by the subcommittees delegate focused attention and accountability of critical PWSRCAC activities.

The PWSRCAC technical committees direct the majority of the research, document review, and policy recommendations that are presented to the board (PWSRCAC 2012). Each technical committee concentrates on a particular aspect of risk management for which it advises the BOD. The technical committees include Oil Spill Prevention and Response, Port Operations and Vessel Traffic System, Scientific Advisory, Terminal Operations and Environmental Monitoring, and Information and Education. Members are public volunteers that are appointed through a formal application process based on expertise, interest, and willingness to serve. Project teams and working groups are formed to lead specific activities within each technical committee.

Project teams are lead by committee members, but often include other staff, board members, contractors and public volunteers (PWSRCAC 2012). The teams meet frequently to assist internal project scoping and progress. They are responsible for RFP review, contractor selection, ongoing project review and recommendations. A technical committee will assign a working group to a project when additional input is deemed necessary. As with all recommendations, they are only advisory and must be approved by the appropriate technical committee.

Working groups are multi-stakeholder project collaborations that can be initiated by PWSRCAC, the oil industry, or a government agency. Previous working groups have been created to develop new projects, regulations, and statutes. All PWSRCAC commitments require board approval before work begins.

In addition to the many volunteer positions, PWSRCAC has 16 permanent and paid staff members responsible for the ongoing activities in the two offices located in Anchorage and Valdez (PWSRCAC 2012). The positions include the executive director, executive assistant, director of external affairs, outreach coordinator, director of programs, administrative assistant, financial manager, seven project managers, and two assistant project managers. All the staff are hired and required to report to the executive director.

The PWRCAC design has institutionalized numerous internal checks and balances that provide a high level of integrity and accountability. Additionally, there are many external audits that occur annually to ensure intended purpose. An annual independent audit is conducted on all finances. Additionally, the United States Coast Guard is mandated to conduct an annual recertification of the group to confirm compliance with OPA 90 requirements (PWSRCAC 2011).

2. Critical Design Factors

In summary, PWSRCAC influence in the risk governance system is related to its structural and procedural design. The most critical design factors identified include ***representation***, ***independence***, ***transparency***, ***resource accessibility***, ***collaborative capacity***, and ***institutionalization***. Other components are also important contributors, but seem to either be nested in these more general criteria or have a less significant role.

Representation is important because it ensures that all interests have an opportunity for equal voice and influence (Reed 2008). Leveraging diverse interests helps formulate a broader systems perspective of the risk governance issues and safeguard against unintended consequences. ***Independence*** allows PWSRCAC the flexibility to choose risk issues that are of greatest concern to the stakeholders at most risk. The organization is not bound by obligations or contingencies of any other entity or alternative interest. Independence promotes an organizational agenda that it reflective and responsive to the public interest (PWSRCAC 2011). ***Transparency*** is closely related because it ensures that other stakeholders, especially the public, have a clear understanding of PWSRCAC actions, motives, and interests (Steiner 2007). Maintaining independence and transparency is important to maintain credibility and allow appropriate accountability.

Resource accessibility is also a major contributor of PWSRCAC success. PWSRCAC has greater access to resources than any other citizen advisory council in the research literature (Busenberg 2000). Financial resources enable PWSRCAC to conduct independent research, hire quality staff, and purchase research equipment. Access to industry facilities allows for direct inspections and monitoring. Political access provides insight into legislative activities and additional pressure behind recommendations (Busenberg 2000).

Collaborative capacity allows PWSRCAC to leverage recommendation support and project resources from other stakeholders in the risk governance system. Partnerships and iterative interactions with other stakeholders can also improve overall communication and the system responsiveness. Reduced stakeholder conflict also protects against project delays and duplications (Busenberg 1999b).

Institutionalization is another distinguishing and important feature of PWSRCAC process and design. Since the citizen advisory group is a permanent institution in the risk governance system, participants can benefit from long-term learning and repeated experiences (Reed 2008). As a result, other important components such as early and continuous involvement, interaction, participatory philosophy, competence, tailored methods, and integration of local and scientific knowledge may emerge naturally or be easier to achieve.

The critical development and design factors are also identified in bold italics throughout the outcome analysis framework.

C. Risk Context Framework Analysis

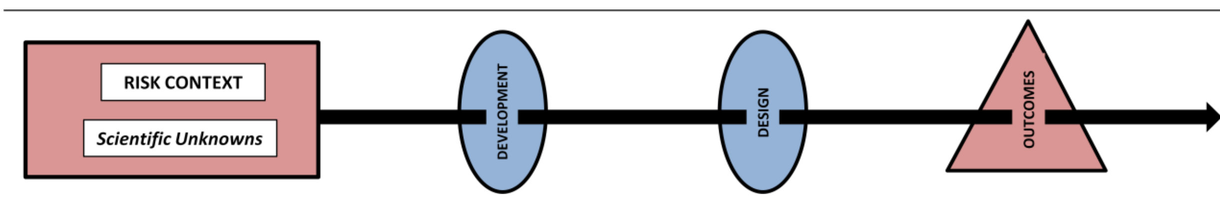
The risk context framework analysis is used to identify the conditions that most warrant the implementation of elaborate participatory approaches. Nine relevant risk factors from the International Risk Governance Council (2010) report, *The Emergence of Risks: Contributing Factors* are used to describe the risk context before the PWSRCAC creation. Then, the most critical contextual factors and underlying themes are identified and discussed. The risk context criteria are also examined in the outcome analysis framework to illustrate how PWSRCAC has changed these contributing risks factors.

1. Descriptive Analysis

Scientific Unknowns

Prior to the EVOS, the system had abundant scientific unknowns related to oil spill risks. The overlapping environmental and technological systems both involve complex relationships with a multitude of components that contribute to risk. Scientific analysis cannot reduce all the uncertainty in such a complex system, but it is an important first step. The scientific unknowns present in the risk governance system before the EVOS resulted from two sources: inaccurate scientific analysis and a lack of scientific analysis all together. As a result, oil spill prevention and response proved to be inadequate before the EVOS.

Grabowski (2000) has created a risk event error chain to illustrate how the technological, environmental, and human systems can interact to cause oil spill (Figure 6). A triggering event can initiate any one of



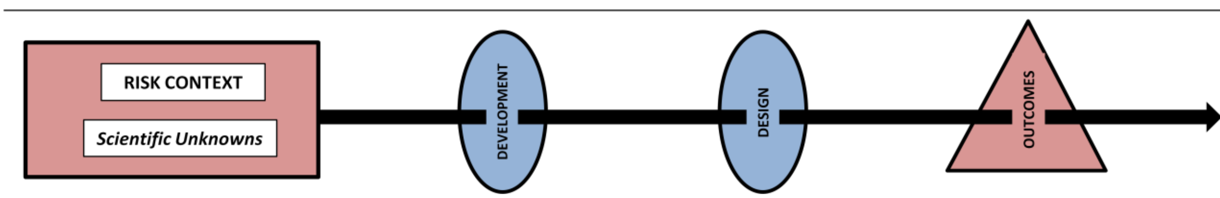
innumerable risk pathways that cascade into an oil spill. The root causes are usually organizational factors while the intermediate are often situational. However, the system as a whole is incredibly complex and often unpredictable. Prevention requires extensive information about the relationship components so that firewalls can be appropriately designed and implemented. However, prevention is only half the challenge.

Not all oil spills can be prevented. Minimizing risk requires additional information on processes and tools that can enhance response and mitigate consequences (GAO 1989). Harrald et al. (1990) illustrates the complex decision making process and information requirements involved during a response in Figure 4. Optimal decision making requires information about response technology, human capacity, and environmental factors that affect the oil spill behavior. Both prevention and response require tremendous information about complex relationships. Uncertainty is high and often irreducible.

Actual risk assessments before the EVOS could not be found. However, some inadequacies are evident in the contingency plans used at the time. The risk governance system had six different contingency plans available to direct oil spill preparation and response during the EVOS (The National Response Team 1989). However, most of these plans underestimated the potential oil spill size. The risk assessments underlying the predictions used historical data and the best available technology (Harrald et al. 1990). Therefore, the contingency plans were not designed for worst-case scenarios and were inadequate for low probability, high consequence events (National Response Team 1989, Harrald et al. 1990). The scientific uncertainty involved came from a lack of system predictability.

Clean-up technologies were another issue that was associated with high uncertainty. The low oil recovery rates highlighted technological inefficiencies and implementation challenges that had not been adequately considered. Some technologies, such as chemical dispersants and beach washing, were implemented without adequate information on effectiveness or potential side effects (Harrald et al. 1990).

In general, high scientific uncertainty contributed to risky management decisions before and during the EVOS. It is acknowledged that some uncertainty may not be reducible because of the system



complexity. However, the high amount of uncertainty present in the system before the EVOS indicates that more resources could have been allocated to greater reduction.

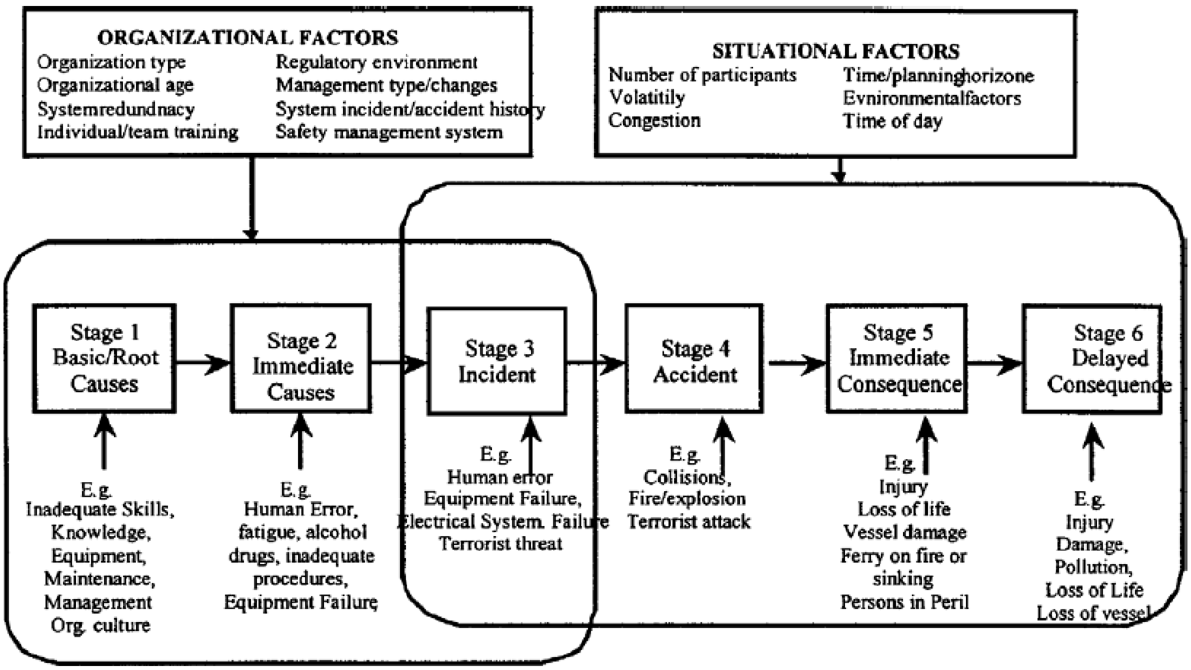
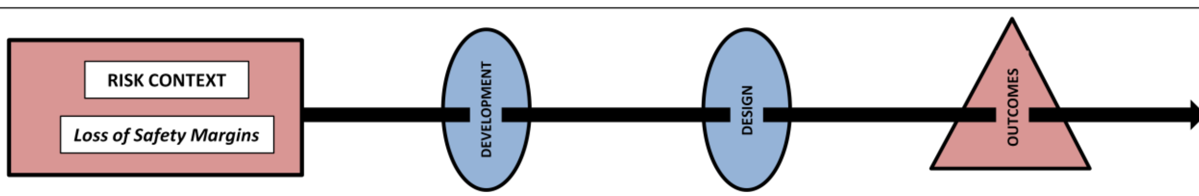


Figure 6. Risk Event Error Chain (Grabowski, et al. 2000)

Loss of Safety Margins

Oil spills occur from tight coupling between factors within the complex technological and environmental systems. An oil spill is the culmination of cascading events that occur through a risk pathway. Prevention requires firewalls to intercept or buffer the cascading events that lead to an oil spill (Grabowski et al. 2009). PWS is a particularly vulnerable system because it includes environmental factors not present in other oil terminal and tanker networks such as icebergs, multi-directional winds, shallow reefs, and often stormy seas (Merrick et al. 2000, Busenberg 1999b). The added complexities warrant additional safeguards to divert disaster.

The firewalls present before EVOS were inadequate to buffer the many risk pathways present in the system. To begin, regulatory deficiencies encouraged noncompliance behavior. The United States Coast Guard (USGS) is responsible for the oversight of ship design and construction, manning of ships, and ship movements (The National Response Team 1989). At the time, the USGS was not allocating enough



resources towards quality personnel and regular inspections. Government monitoring and enforcement were inadequate to establish a risk cognizant system.

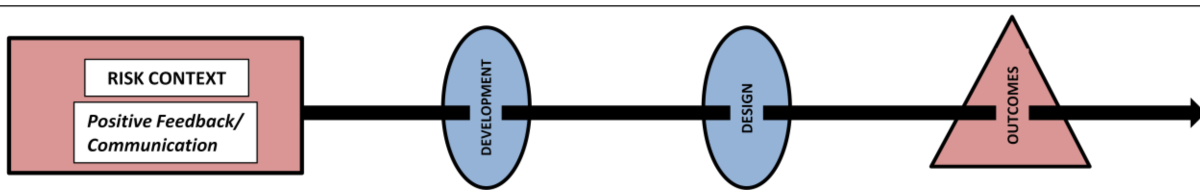
The system also lacked proper technological firewalls that could have prevented the EVOS. The tracking system that used radar to assist transportation safely through the PWS had been reduced prior to the incident (GAO 1989, Busenberg 2008). Additionally, the vessels intended to readjust tankers that accidentally go outside the shipping lanes were not in position to help the Exxon Valdez. As such, the system was unable to detect or respond to the navigational error that directed the Exxon Valdez into Bligh Reef.

Oil spills are not completely preventable. Therefore, response plans and equipment are important safety buffers that need to be established in vulnerable systems. EVOS illustrated that the system did not have adequate response buffers to mitigate major oil spills. Contingency plans were not designed for worst-case scenarios, response equipment had not been maintained, workers lacked necessary training, and the oil spill response team had been disbanded (Busenberg 2008, The National Response Team 1989).

Positive Feedback/Communication

The positive feedback between the risk actors and the public was relatively weak prior to the PWSRCAC development. Communication was usually directed one-way from the oil companies to the other stakeholders. Other communicative feedback about system risks was often ignored. The public had repeatedly expressed concerns to government agencies that were not addressed in time to prevent the EVOS. One public concern involved the intoxication of oil tanker workers. The public concern came from the high prevalence oil tanker workers at local bars. However, no obvious action was taken to redress the public concerns (Alaska Sea Grant 1989).

In another case, the City of Valdez brought attention to the inadequate local capacity for an oil spill response. The city used an additional tax on the Alyeska property to fund improved planning and response equipment. However, the city's concern for sufficient response equipment was overshadowed by a legal battle over the discriminating tax (PWSRCAC 2000). The lawsuit was underway at the time of



the EVOS. In both cases, public feedback highlighted weakness in the risk system without any corrective action in response.

Feedback among government agencies and industry companies was also weak. For example, after an investigation of a prior spill in 1979, the Department of Transportation recommended that PWS increase the response equipment available and research new technologies. However, the recommendations were never implemented (Alaska Sea Grant 1989).

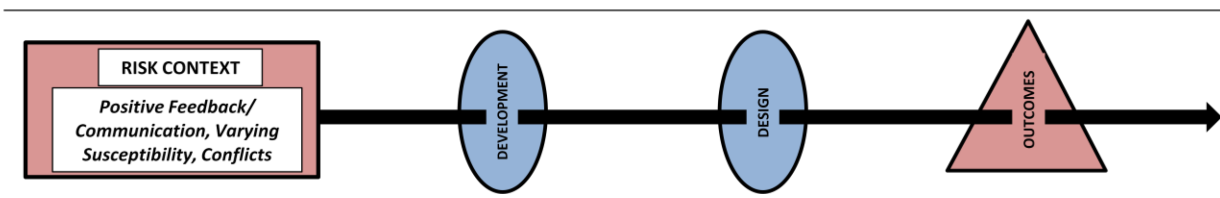
The feedback during the response also increased risk by exacerbating the oil spill severity. The many different stakeholder groups involved in the response lacked clear roles and responsibilities (The National Response Team 1989). Communication problems due to poor radio coverage further complicated the issue. As a result, adversarial relationships developed and reduced the efficiency of the clean up (The National Response Team 1989).

Varying Susceptibilities to Risk

Prior to EVOS, the distribution of benefits and risk was highly disproportional. Industry acquired economic profits with very little risk. Coastal communities, indigenous populations, and other industries that depend on surrounding Alaskan ecosystem acquired only secondary economic benefit, but a large proportion of risk. Moreover, the risk governance system was not structured to channel concerns from these groups directly into risk management processes. On numerous occasions, vulnerable populations challenged the current risk governance strategies (PWSRCAC 2000, Busenberg 2011). However, the groups were routinely defeated or ignored (See Feedback for more information).

Conflicts about Interests, Values, and Science

The risk governance system was very contentious prior to the PWSRCAC development. Conflicts between oil development and environmental protection had been ongoing since the large oil reserves were found along Alaskan northern coast in 1968 (Busenberg 2011). First, indigenous groups had to compete for land claims that had not been resolved since Alaska obtained statehood. Then, when the Trans-Alaska pipeline was proposed, other environmental groups joined to directly contest the scientific



assessments. Collectively, the public stakeholders generated four volumes of counter-arguments, many of which relied on scientific critiques by independent experts (Busenberg 2011).

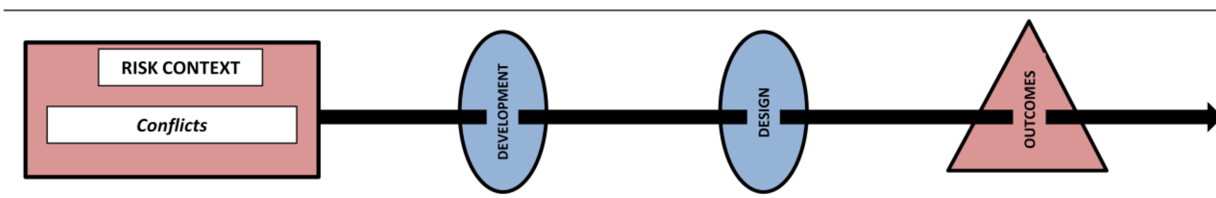
The contentious balancing of oil development and environmental protection has been an ongoing endeavor in Alaska. Even after the Trans-Alaska pipeline and oil terminal were well-established, conflict between industry and environment stakeholders persisted. For example, the City of Valdez and Alyeska were involved in an ongoing lawsuit with the State of Alaska during the EVOS (PWSRCAC 2000). The City of Valdez had placed an extra tax on the Alyeska property to fund an environmental service area that could better respond to major oil spills. The money would have been used to purchase extra containment booms, skimmers, and other equipment (PWSRCAC 2000). Eventually, the City of Valdez was forced to remove the tax because it was discriminatory treatment of the Alyeska Pipeline Service Company. The decision to overturn the tax followed the EVOS incident and likely contributed to growing public distrust.

The immediate conflict between industry and RCACs in the years following the EVOS also illustrates the distrust embedded in the system prior to the new institutional structure. It is used here, in the risk context analysis, to represent the conflicts that would have likely occurred given a more structured opportunity. A GAO evaluation (1993) of the AK RCACs indicated that industry and government agencies often contested RCAC risk assessments for either being unnecessary duplicates of previous studies or flawed due to inappropriate modeling choice and unqualified consultants (GAO 1993).

Distrust was also provoked by adversarial information sharing between industry and the RCACs. The RCACs often released contentious information to the public, including the media, without industry notification or consultation (GAO 1993). Meanwhile, industry was unwilling to provide all available data requested by the RCACs. Only after years of repeated interactions did the stakeholders start moving towards greater collaboration and mutual understanding (Merrick et al. 2000). The initial interactions explicitly illustrate the conflict and distrust within the system prior to the RCAC development.

Social Dynamics

There is acknowledged uncertainty regarding the social dynamics within the risk governance system prior to EVOS. However, the oil industries had historically relied on image manipulation, industry-



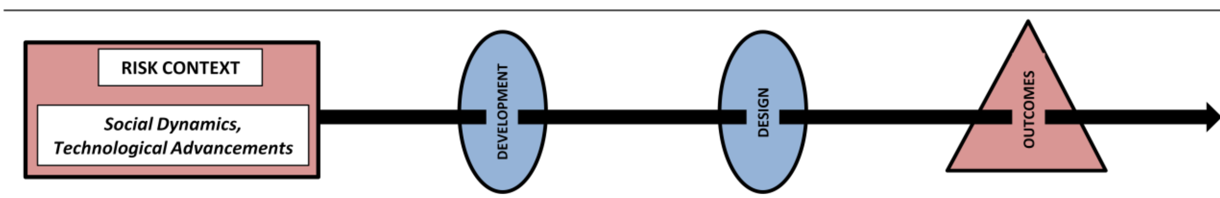
sponsored research, and economic considerations to maintain public support (Kurtz 2004). Public relations framed oil spill incidents as random anomalies that could not have been avoided. Industry assumed that it could alleviate public fears by assuring that voluntary actions were taken to prevent a duplicate incident. The public did not have easy access to information that proved it one way or another. Public interest groups were often unable to disprove the industry produced information.

Additionally, the social dynamics specific to PWS region had a contentious history that often flared up between industry and environmental interests (Busenberg 2011). Numerous groups had repeatedly come together to fight the expansion of oil development throughout the years (Busenberg 2011, PWSRCAC 2000).

The social dynamics intensified dramatically just after the EVOS. The USCG established a news office after the EVOS, but it was overwhelmed by the outpouring of public interest for the event (The National Response Team 1989). Additional public affairs staff needed to be called in to assist ongoing public response and outreach. The large media influx made it even more difficult to aggressively communicate with the public. Phone lines were often jammed and misinformation was hard to control. After the response ended, the public appeared in record numbers to the Exxon Valdez public hearings and protesters cut up gas cards at the Exxon corporate offices (Kurtz 2004). Overall, the social dynamics were antagonistic.

Technological Advances

Technological risk is the main component of the risk governance system. Prior to the EVOS, industry had little incentive to increase flexibility, innovation, or urgency surrounding technological risks. Oil terminal activities and tanker transportation were familiar operations and no major spill had occurred in PWS since operations began. Industry focused on maintaining the status quo with research studies and media campaigns that assured system safety (Kurtz 2004). Other stakeholders had also become lulled into a false security that operations utilized the appropriate amount of risk precaution. There was minor pushback from some public voices that the system needed to increase safeguards, but no obvious action was taken. No evidence was found describing any incentives driving increased flexibility and innovation.



Temporal Conditions

The regulatory deficiencies that contributed to the EVOS occurred because of a gradual decrease in system vigilance. As time went by without a major spill, risk governance stakeholders began reallocating internal resources to other activities. The oil industry began making statements about the lack of danger from spills and cut its entire fulltime pollution response staff (Harrald et al. 1990, Alaska Sea Grant 1989). During a time of budget cuts, the USCG also reduced its pollution response experts. It started using only one observer for the Vessel Transportation System (VTS) and delegated the vessel inspections to the American Bureau of Shipping (Harrald et al. 1990).

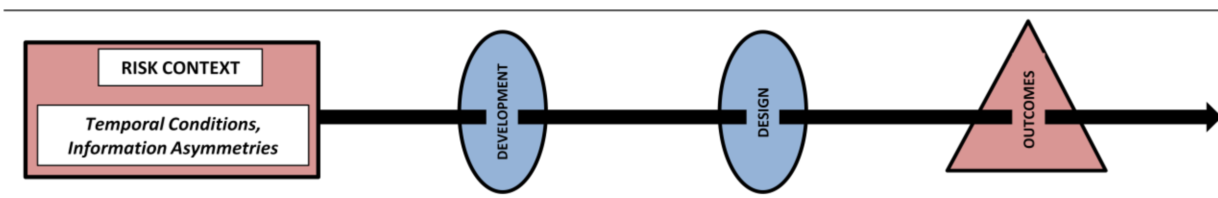
The gradual reduction in safeguards made it more difficult to detect risks and respond to oil spill events. Decreasing safety personnel and technology safeguards literally reduced the risk sensors in the system. Moreover, it indicates a cultural shift in the system perception of risk. Response was likely to lack the necessary urgency because the potential severity of the event is underestimated.

Information Asymmetries

Prior to the EVOS, the oil industry and government agencies operated in isolation from the public realm (Steiner 2007). Information asymmetries were large since industry generated most of the information that was available to other stakeholders (Kurtz 2004). The public did not have the resources to validate information and risk claims. Instead, the public had to trust that the government agencies (USGS and ADEC) were upholding the public interest. However, a lack of resources and close professional relationships with industry made it difficult for government agencies to do so (Alaska Sea Grant 1989). Without transparent and accurate information, the public was unable to hold government agencies accountable to public interests. As a result, technological risk was not adequately managed.

2. Critical Risk Context Factors

Prior to the EVOS all nine of the IRGC risk factors analyzed in this paper were amplifying the risk of oil spills in PWS. High scientific uncertainty, limited risk firewalls, stakeholder conflict, and time induced complacency were complex challenges that the governance institutions were unable to manage adequately. However, the distinguishing feature of the risk context is not necessarily any one particular risk factor, but the high degree of interaction among them.



The risk factors are highly interconnected and ambiguously correlated. This phenomenon is likely reflective of the tight coupling among the complex technological, environmental, and social systems. These complex relationships require extensive effort to reduce uncertainty. However, residual uncertainty will often remain because of irreducible complexity and inherent unpredictability. Adequate risk management requires buffering residual uncertainty.

The characteristics of the risk context that made PWSRCAC an appropriate policy stem from the multiple ***overlapping and tightly coupled systems*** (technology, environment, human). First, ***high complexity*** of these systems and their interactions led to ***high uncertainty***, often difficult or impossible to reduce. Second, there were limited risk firewalls to buffer system risk and uncertainty. Third, the risk of an oil spill is a ***low probability, high consequence event*** that is both ***difficult to predict*** and ***maintain ongoing vigilance.*** Fourth, stakeholder ***value conflicts*** between tightly coupled industry and environmental systems were persistent. Other factors that merit mentioning include the ***limited communication feedback*** and rising ***public distrust***. These risk context conditions warranted a more integrated risk governance system that leveraged greater public participation.

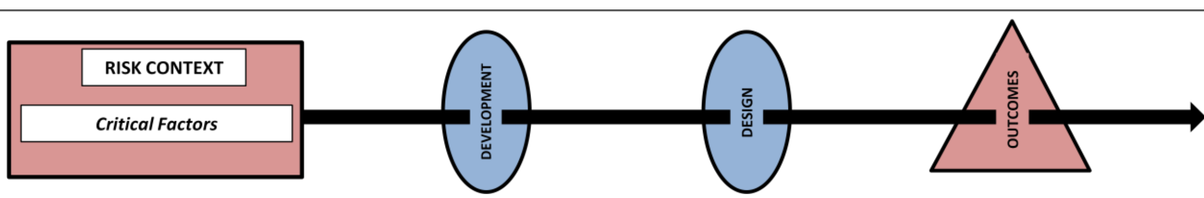
D. Outcomes: IRGC Risk Factor Analysis

The outcome framework analysis is used to describe how the risk context has changed since PWSRCAC has been established in the risk governance system. First, the nine relevant risk factors from the International Risk Governance Council (2010) report, *The Emergence of Risks: Contributing Factors* are reexamined. The change in each risk factor that is attributed to PWSRCAC is described. It is acknowledged that the contributions from the PWSRCAC cannot always be isolated. The critical development and design factors that affect the outcomes are identified in bold italics throughout the analysis. Following the IRGC risk factor analysis, the most outcomes are identified and discussed.

1. Descriptive Analysis

Scientific Unknowns

Scientific research is a major activity pursued by PWSRCAC. Since it was established, the PWSRCAC has initiated numerous projects that have decreased scientific uncertainties within the risk governance system. To date, the PWSRCAC has 36 projects related environmental monitoring, oil spill prevention,



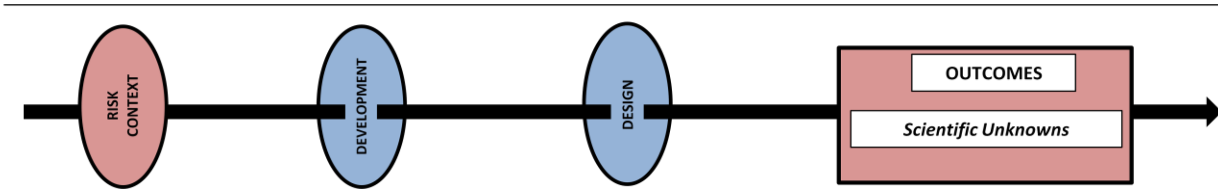
oil spill response, terminal operations, maritime operations, and non-indigenous species (Figure 7; PWSRCAC 2012). These projects explore scientific unknowns related to maritime oil pollution hazards and many have influenced decisions by industry and Alaskan state agencies to adopt new risk management policies. PWSRCAC often works in collaboration with industry and government agencies to conduct many of these projects. However, PWS RCAC is often responsible for channeling attention to scientific unknowns that need more attention.

OPA 90 mandates PWSRCAC to conduct ***long-term monitoring of environmental conditions*** in the EVOS region that could be used in baseline assessments (Busenberg 2007). Without baseline information, it is difficult to accurately determine oil spill damages. However, PWSRCAC has taken action beyond the OPA 90 mandate by partnering with the Exxon Valdez Oil Spill Trustee Council (EVOSTC) to conduct larger scale research pertaining to the broader Gulf of Alaska ecosystem (Busenberg 2007).

Most of PWSRCAC research directly focuses on oil spill prevention and response. For numerous projects, PWSRCAC has ***initiated research*** related to scientific uncertainties widely acknowledged, but consistently ignored by other risk governance stakeholders. For example, industry and government officials recognized environmental risks related to weather and icebergs, but neither proposed better detection equipment (Busenberg 2008). It was PWSRCAC that initiated research to better understand these risks, which eventually lead to important management changes (Busenberg 2008, 1999a).

In addition to assessing known uncertainties, PWSRCAC conducts projects to evaluate potential risks not previously considered. The risk assessments support ongoing research projects and policy proposals. Notable examples include risk assessments on tug escorts, wind conditions, and marine fire training that led to risk management improvements (Busenberg 2008, Busenberg 1999a). PWSRCAC has also contributed to a greater understanding of the human factors that contribute to technological risk. In 2006, PWSRCAC released a risk assessment that recommended ***integrating human factor analysis*** into future oil spill risk assessments (Nuka Research and Planning Group, LLC 2006).

The culmination of PWSRCAC projects has significantly reduced the scientific uncertainty within the risk governance system. The organization has increased the number of risk assessments conducted on the system. Additionally, it has increased the amount information available regarding risk mitigation



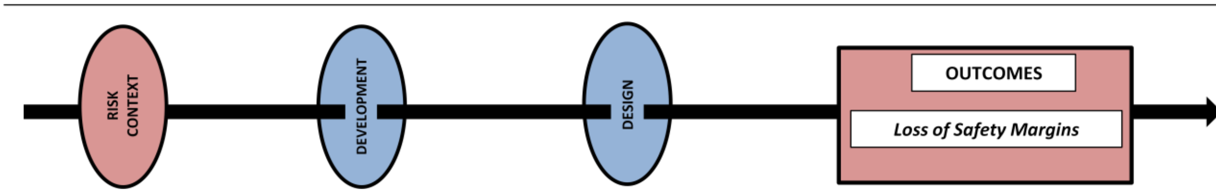
strategies and technology. These activities have been widely document in the literature and are made ***transparent*** through numerous public relation efforts. In summary, the PWSRCAC has significantly reduced scientific uncertainty by conducting long-term monitoring, initiating research, acknowledging a broader view of risk assessment, and creating transparency.

Program	Projects
Oil Spill Response	Fishing Vessel Training, Incident Response Plan, Oil Spill Response Gap, Preparedness Monitoring, Telecommunications in PWS, Tethered Balloon Oil Spill Surveillance System
Oil Spill Prevention	Coastal Management, Community-based Response, Contingency Plan Reviews, Coping with Technological Disasters, Geographic Response Strategies, Shore Zone Mapping, Weather Data
Terminal Operations	Ballast Water Treatment Facility, Corrosion Abatement, Dismantling/Removal/Restoration Fund, Fire Protection Systems, Microbial Efficiency, Non-dispersing Oil Spill Response Technologies, National Pollutant Discharge Elimination System Permit, Reconfiguration of Valdez Marine Terminal, State of the Environment, Valdez Air Quality
Maritime Operations	Ice Detection, Marine Firefighting, Place of Refuge, Tanker Escort System
Environmental Monitoring	Biodegradation of Dispersed Crude Oil in the Prince William Sound Region, Copepod Testing, Dispersants, In-situ Burning, Long-term Environmental Monitoring, Sediment Coring, Science Night
Non-Indigenous Species	Non-Indigenous Species & Ballast Water, Non-Indigenous Species Bibliographic Database

Figure 7. PWSRCAC Programs and Projects (PWSRCAC 2012).

Loss of Safety Margins

PWSRCAC increases safety margins both as a risk management strategy itself and a creator of new risk management strategies. As a risk management strategy itself, PWSRCAC ensures ongoing risk vigilance within the system (Busenberg 1999a). Since other risk governance stakeholders have broader responsibilities and interests, they are not always capable of allocating the appropriate resources and attention to the cause. Since PWSRCAC focuses all of its ***resources*** on oil spill risk reduction it ensures safety margins are maintained. To do so, PWSRCAC monitors industry operations and legislative activities to ensure allocated risk resources are not reduced.

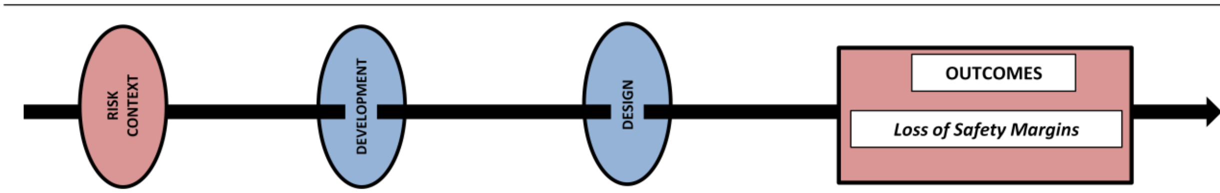


As a creator of risk management strategies, PWSRCAC has helped increase system safety margins. With its ***narrow risk focus*** and ***communication among stakeholders groups***, PWSRCAC has been able to identify risks and initiate research and policies to establish necessary firewalls (Busenberg 2008). Preliminary research from PWSRCAC spurred collaborative action that eventually lead to a network of buoyed weather sensors, a responsive tug escort system, and an advanced ice detection system (Busenberg 2008).

The improved weather reporting system was directly proposed by PWSRCAC in 1993. The proposal was immediately supported by industry and government agencies alike (Busenberg 1999a). They acknowledged that weather unknowns enabled tankers to leave the Valdez terminal under dangerous conditions. Improved weather information about ocean conditions beyond the terminal could keep tankers out of risky situations. This widely supported management firewall was only possible because PWSRCAC initiated a proposal that could be discussed more broadly.

In another case, a PWSRCAC survey ***triggered a series of collaborative actions*** that lead to another firewall in marine ice detection. A PWSRCAC survey given to tanker officers indicated that traditional ice monitoring that used periodic vessel reports and satellite imagery was insufficient (Busenberg 2008). The perceived risk from icebergs entering shipping lanes was significant enough to initiate a research collaborative that monitored icebergs from the Columbia Glacier. PWSRCAC was an ongoing partner through the initial research, strategy development, and final deployment of a highly advanced ice detection system. The new ice detection system acts as a collision firewall by increasing navigation safety through the PWS (Busenberg 2008, 1999a). PWSRCAC was the first organization to propose additional research and improvements.

PWSRCAC has also been highly involved in tug escort firewalls that are used to keep tankers in the designated shipping lanes through the PWS (Merrick et al. 2000). After advocating for more maneuverable tractor tug escorts and an ocean rescue tug, PWSRCAC ***partnered with industry*** to do a comprehensive risk assessment. Industry implemented the ocean rescue tug in accordance with the risk assessment results. The AK state government required implementation of the tractor tug escorts even though their effectiveness was inconclusive in the risk assessment. The escort tug firewalls would not have been possible without the incessant advocacy by PWSRCAC.



Regulatory changes after the EVOS mandated other firewalls that the system was previous lacking. Some of these mandates include double hull tankers, alcohol testing, marine fire training, an updated vessel tracking system, and greater supply of response equipment. PWSRCAC cannot take credit for any of these other important firewalls per se. However, PWSRCAC has had an important role in ***monitoring implementation***. In summary, PWSRCAC contributions in the risk governance systems have significantly improved the safety margins by leveraging its resources, dedicated risk jurisdiction, and collaborative capacity.

Positive Feedback/Communication

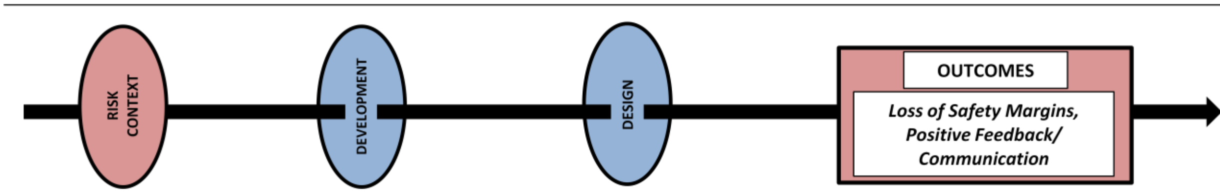
PWSRCAC increases positive feedback in the system by forcing greater ***transparency*** and ***creating dialogue*** among traditionally disparate stakeholders. Meetings provide ***open public forums*** where PWSRCAC members, interested public, industry representatives, and government officials can exchange updates, concerns, and proposals related to the risk system. A GAO report (1993) concluded that that the AK RCACs "substantially increased the level of citizen' involvement with the oil industry and with government regulators in environmental oversight of oil terminal and tanker operations".

PWSRCAC further closes the gap between the risk governance institutions and the public by ***increasing awareness***. The ***public outreach program*** keeps the public abreast on industry operations and legislative proposals that could amplify or attenuate risk. Simultaneously, concerned public have an organization specifically established take ongoing citizen oncerns and channel them to decision makers.

The presence of PWSRCAC has encouraged ***long-term partnerships*** among itself, industry, and government agencies (PWSRCAC 2011). The stakeholders do not always agree, but they are ***regularly consulted*** about current activities and plans. It increases the system awareness and helps ***coordinate plans and actions*** that reinforce positive risk management strategies. PWSRCAC significantly increased the positive feedback and communication in the system through its ability to build public capacity, engage with stakeholders, and adhere to transparent practices.

Varying Susceptibilities to Risk

PWSRCAC establishes an institutionalized voice for the regional populations most vulnerable to oil spills in PWS. The new liability policies enacted after EVOS increased the industry risk, but did not directly



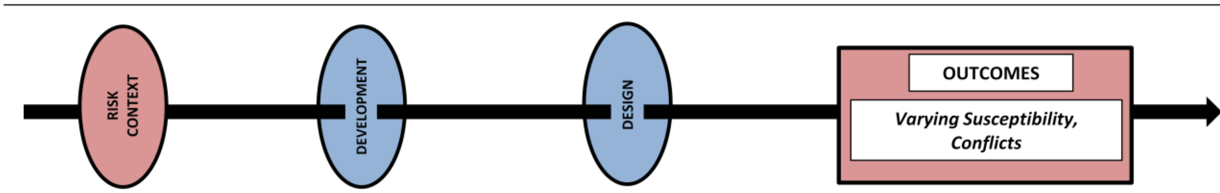
assist vulnerable populations. PWSRCAC does not directly decrease the risk placed on vulnerable populations either, but it gives them an ***organized method to do it themselves***. Permanent access into the risk decision-making process allows representatives to increase their knowledge about the risks and the management system. Consequently, vulnerable populations are ***better equipped to influence*** the decisions that will affect them. In essence, it levels the policy playing field.

In addition to providing ***greater voice***, PWSRCAC has been directly involved in preparing vulnerable populations and distributing coping tools to mitigate social impacts. For example, PWSRCAC initiated a marine fire ***training program*** to improve oil spill response and decrease risk of worker injury. The fire training was a recognized need in the system, but continuously "ignored because it fell in between the jurisdictional responsibilities". By closing this management gap, PWSRCAC has made fire fighters less vulnerable in oil spill response.

PWSRCAC has also been ***responsive to the expansive array of social effects*** that can stem from technological disasters. It created a "Coping with Technological Disaster" guidebook and DVD for communities seeking strategies to better handle social disruptions and psychological stress. All of these examples illustrate how PWCRCA has created opportunities for vulnerable populations to help themselves reduce potential and/or inflicted risked. In general, PWSRCAC somewhat improved the varying susceptibilities to risk. Its contribution does not actually redistribute the risks and benefits, but it does empower vulnerable populations by increasing their education, voice, and training.

Conflicts about Interests, Values, and Science

The PWSRCAC has significantly decreased the conflict around interests, values, and science. In doing so, it has improved risk assessment process, including the problem definition, assumption choices, and result interpretation. High conflict can deteriorate trust among stakeholders, but more collaborative risk assessment is expected to rebuild it (Busenberg 1999b). Since the EVOS and creation of the PWSRCAC, the risk governance system has evolved towards a more consensus approach and away from the traditional adversarial approach (Busenberg 1999b). However, the transition has included a learning curve among participants. ***Repeated long-term interactions*** likely increased the opportunity to decrease conflict and rebuild trust. Conflicts around terminal air emissions and tractor tug vessels illustrate the collaborative transition.

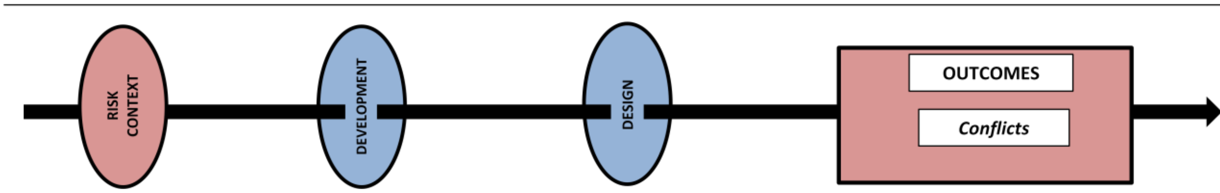


A terminal air emissions conflict started when the oil industry refused to give PWSRCAC the air quality data it requested to conduct an independent study (GAO 1993). An industry risk assessment had already evaluated airborne benzene in the City of Valdez. When the PWSRCAC airborne study was completed in 1992, the stakeholder conflict intensified because the results completely contradicted the previous industry assessment. The PWSRCAC concluded that 90% of the benzene originated from the oil terminal and proposed the installation of vapor emission controls (Busenberg 2000, 1999b). However, the industry study concluded that it was only responsible for 25% of the airborne benzene and therefore refused to install emission controls (Busenberg 2000, 1999b).

The scientific validity of both studies was questioned as opposing sides assumed intentional manipulation (Busenberg 1999b). In 1993, industry and PWSRCAC finally decided to ***partner*** another study to break the deadlock and restore credibility. However, the collaboration was interrupted when the U.S. EPA established federal regulations for oil terminal emissions. To comply with the Clean Air Act, the Valdez terminal had to reduce 95% of *all* hazardous emissions (Busenberg 2000, 1999b). Regardless, the air emissions conflict illustrates how stakeholders began shifting towards a more ***collaborative approach*** to curtail conflict, delay, and distrust.

Eventually, the PWSRCAC established protocols to discuss project design and review study results with industry officials (GAO 1993). Experience from the air emission conflict and the new communication procedures helped alleviate a subsequent conflict that surfaced about tug escort vessels. In 1994, the PWSRCAC proposed replacing current tug escorts vessels with more maneuverable tractor tug vessels and adding an ocean rescue vessel to the system (Busenberg 1999a, 1999b, Merrick 2002). Industry opposed the proposal because it viewed the new vessels as unnecessary expenses (Busenberg 1999b). Instead of doing independent studies, the stakeholders collaborated in a comprehensive risk assessment of marine oil transportation in PWS.

In 1995, the four main stakeholders (industry, PWSRCAC, ADEC, USGS) formed a steering committee to design and adjust the comprehensive risk assessment used to inform the tug escort debate (Merrick 2002). Initially, industry and PWSRCAC remained skeptical of each other. They hired separate research teams and disagreed over which one should be used use (Busenberg 1999b). However, they eventually combined teams and set additional ground rules for the rest of the process. The collaborative approach



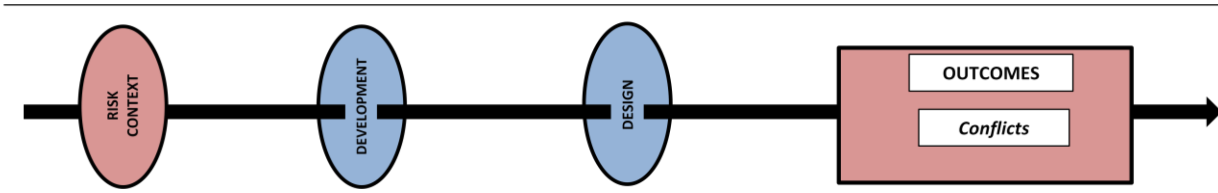
involved educating the steering committee members about scientific language and risk modeling, developing a common framework, choosing the alternatives, and discussing assumptions (Merrick 2002). All decisions required ***unanimous consent*** and all ***costs be shared*** (Busenberg 1999b).

The collaborative approach strengthened the risk assessment in numerous ways. The broad perspectives deepened the problem understanding, increased the available data, and unveiled the modeling assumptions (Merrick 2002). For example, after deciding that the historical data records were insufficient, the steering committee leveraged the diverse knowledge from the community to be used in the assessment (Merrick 2002, Busenberg 1999b). Uncertainty and assumptions were explicitly addressed by the stakeholders and in the assessment itself. The final report states,

> "...the reader should recognize that the value of an analysis is not in the precision of the results per se, but rather in understanding the system through the identification of peaks, patterns, unusual circumstances and trends in the system risk and changes in system risk through risk mitigation (Merrick 2002)."

As such, the final risk assessment was co-authored and released by all stakeholders with unified acceptance (Busenberg 1999b, Merrick 2002). In 1997, industry deployed an ocean rescue tug in lieu of the results. The government later mandated tractor tug escorts as the best available technology despite inconclusive results in the collaborative risk assessments. However, the collaborative approach had other external benefits including: pooled resources, mutual learning, and offset suspicion (Busenberg 1999b).

Collaborative projects have become an important risk governance strategy since PWSRCAC has become more established. Since 1997, PWSRCAC has collaborated on eight other significant projects directed at reducing risk in PWS (Figure 8). Partners have included a variety of stakeholders from industry, government agencies, and universities. Many of the projects are long-term endeavors that are currently active. Collaboration is particularly important for the large projects because it pools resources into a single technical analysis. In summary, PWSRCAC significantly improved conflict due to its repeated interactions, collaborative approach, unanimous consent, cost sharing, and long-term partnerships.

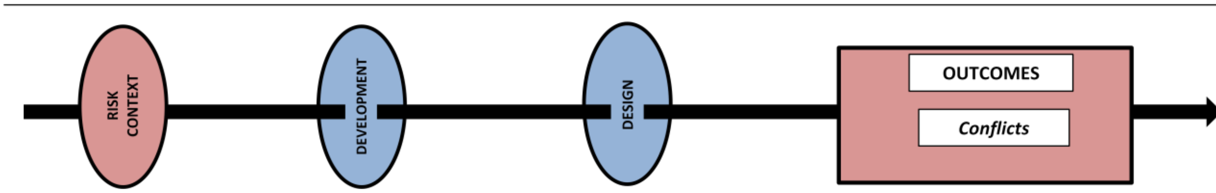


Project	Dates	Partners
Aquatic Nuisance Species Research	1997-present	USFWS, ADFG, USCG, University of Alaska Fairbanks, oil shipping companies, SERVS
Prince William Sound Risk Assessment	1997-1999	USCG, ADEC, Alyeska, oil shipping companies, Southwest Alaska Pilots' Association, SERVS
Remote Ice Detection Radar System	2000-2002	USCG, NOAA, ADEC, PWS Community College, Oil Spill Recovery Institute, U. S. Army, Alaska Tanker Company with Captain & Crew of T/V Denali, North Star Terminal & Stevedore Company, Southwest Alaska Pilots Association, Alaska Foundation Technologies, City of Valdez, Crowley Marine Services, National Guard Armory (Valdez), Roosevelt Towing, Samson Tug & Barge, TCC, VECO
Marine Firefighting Symposium	2003	South West Alaska Pilots Association, USCG, Division of Emergency Services, ATC, SeaRiver, Polar Tankers, PWS Community College, Bullard, Fire Protection Publications
Valdez Marine Terminal Contingency Plan Coordination Working Group	1997-present	JPO (ADEC, EPA, DOI/BLM), APSC
Tanker Contingency Plan Coordination Working Group	1997-2006	USCG, RPG (ATC, ConocoPhillips, SeaRiver),
ARRT Science & Technology Committee Dispersant Working Groups	2003-present	USCG, NOAA, BP, ADEC, DOI, NMFS, USFWS, NPS, BIA, USFS, ADFG, ADNR, CIRCAC, Alaskan Natives and the oil industry.
Geographic Response Strategies Working Groups for Prince William Sound, Cook Inlet, and Kodiak	1997-present	USCG, ADEC, ADFG, ADNR, NOAA, NMFS, EPA, DOI, USFWS, USFS, USMMS, CIRCAC, oil spill cooperatives, shippers and the oil industry.
Acronyms: ADEC-Alaska Dept. of Environmental Conservation, ADFG-Alaska Dept. of Fish & Game, ADNR-Alaska Dept. of Natural Resources, APSC-Alyeska Pipeline Service Co., ATC-Alaska Tanker Co., BIA-Bureau of Indian Affairs, BLM-Bureau of Land Management, BP-British Petroleum, CIRCAC-Cook Inlet Regional Citizens' Advisory Council, DOI-Dept. of the Interior, EPA-Environmental Protection Agency, JPO-Joint Pipeline Office, NMFS-National Marine Fisheries Service, NOAA-National Oceanic and Atmospheric Association, NPS-National Park Service, RPG-Response Planning Group, SERVS-Ship Escort Response Vessel System, TCC-Tatitlek Chenega Chugach, USCG-U.S. Coast Guard, USFS-U.S. Forest Service, USFWS-U.S. Fish & Wildlife Service, USMMS-U.S. Minerals Management Service		

Figure 8. PWSRCAC Collaboration Efforts (PWSRCAC 2012)

Social Dynamics

PWSRCAC has an active public outreach program that provides information and increases broader inclusions on a variety of issues. The group uses radio announcements, media releases, public reports and quarterly newsletters to keep community stakeholders informed about industry activities,



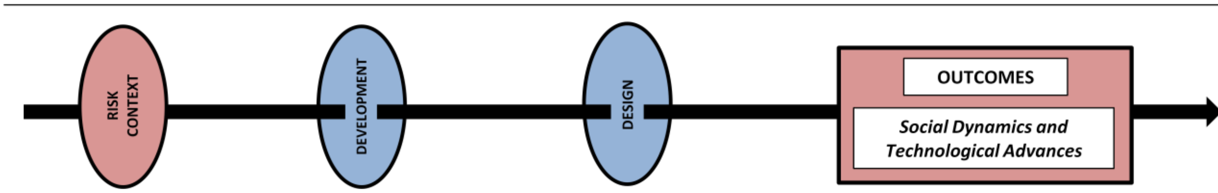
legislative action, and ecological condition of PWS. The outreach program also includes volunteer activities and involvement at community events to get the ***public directly involved*** in ongoing projects (PWSRCAC 2000). Meanwhile, the PWSRCAC website provides a comprehensive and ***transparent*** catalogue of all the information released. The public has a permanent location to find and request information. Should another major oil spill occur in the region, PWSRCAC would likely enhance public relations among the response organizations and the public. To conclude, the PWSRCAC has somewhat improved social dynamics by increasing the inclusion and dialogue among stakeholders.

Technological Advances

The EVOS focused attention on the management weaknesses that could be improved with greater flexibility, innovation, and urgency. There were many regulatory changes after the spill that improved the management of technological risk. New mandates included both technological standards (ex. double hull tankers) and worker standards (ex. Limitations on worker hours) (PWSRCAC 2009). Other regulatory changes created incentives for continuous management improvements. Undoubtedly, the increases in the liability limit have created a larger incentive for industry to increase risk management as a business strategy. However, the introduction of PWSRCAC into the risk governance system has also contributed to greater flexibility, innovation, and urgency.

PWSRCAC increases the ***flexibility*** of the system to better adapt to changing circumstances. PWSRCS has a critical role in monitoring the environmental and social effects related to current and new management strategies. It also has an important role in ***reporting monitoring results*** and ***advocating recommendations*** to the other stakeholders in the system. The process reflects the ***adaptive management strategy***, in which strategies are implemented, monitored, and then adjusted based on the monitoring results (Linkov, et al. 2006). The only difference is that the system is institutionalized and a citizen group is delegated specific roles in the process.

Improvements in innovation and urgency are partly addressed by the other risk factors. For example, PWSRCAC has ***initiated research*** on many unexplored risks that eventually led to the deployment of innovative technology (i.e. network weather sensors, tug escort system, ice detection system; See Safety Margins). Urgency has been improved by increasing the system vigilance throughout time (See Temporal Conditions). In general, the PWSRCAC has improved the flexibility, innovation, and urgency



surrounding technological risks by reporting monitoring results, advocating recommendations, initiating research, and integrating an adaptive management strategy into the system.

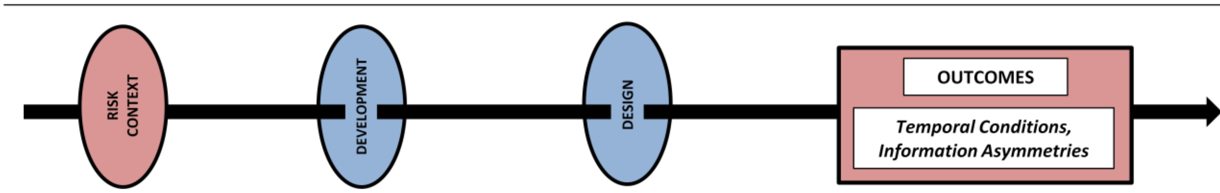
Temporal Conditions

The main purpose of PWSRCAC was to combat complacency and ensure ***ongoing risk vigilance*** in the system. Many of the activities that PWSRCAC pursues are directed towards this end goal. Specific personnel are directed towards monitoring legislative activity and bringing attention to any proposals that could reduce risk in the system, including budget decisions (PWSRCAC 2000). PWSRCAC also periodically reviews terminal operations and tanker standards (PWSRCAC 2009). These third-party oversight activities provide an additional layer of ***accountability*** and increase the ***transparency*** with the public.

Busenberg (1999a) concluded that the new institutional arrangement, defined by the presence of PWSRCAC, has effectively ***protected the system from invading complacency***. Even managers from the oil shipping companies have acknowledged that PWSRCAC forces them to reduce complacency (Busenberg 1999a). Despite two decades since the EVOS, the risk vigilance in the system has not deteriorated as expected. Rather than the expected decreases in safeguards, the system has increased safety margins as more knowledge is generated. In general, the PWSRCA has significantly reduced the negative impacts related to temporal conditions due to its ongoing risk vigilance, complacency deterrence, accountability, and transparency.

Information Asymmetries

Since the PWSRCAC has become institutionalized into the risk governance system the information asymmetries have become more balanced among the stakeholders. PWSRCAC has the ***resources*** to ***generate independent information*** that is then made easily accessible to the public, industry, and government agencies. Initially, PWSRCAC duplicated some industry risk assessments to validate the results (GAO 1993). At the time, distrust was still high and the stakeholders were still using adversarial approaches to interact. Since then, the benefits of collaboration have emerged and now information is more accessible and transparent. Project ***collaboration*** and ***information sharing*** among stakeholder groups is more common, especially for large and/or potentially controversial projects.

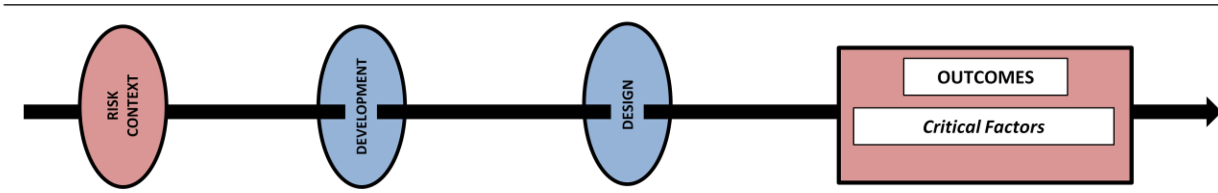


Since the information asymmetries among stakeholders have decreased, the system is more ***accountable*** to the public interests. New scientific risk assessments and other projects need to pass the scrutiny of the other stakeholders to uphold credibility. PWSRCAC also gives the public a larger opportunity to be more informed and involved. Newsletters and media releases summarize issues without technical jargon. In summary, PWSRCAC has significantly improved the information asymmetries by allocating resources, generating independent information, ensuring accountability, and encouraging collaboration and information sharing.

2. Critical Outcome Factors

The outcomes of the PWSRCAC involvement in the risk governance system are evaluated by the change the IRGC risk factors (Figure 9). While there were many policy and institutional changes after the EVOS, analysis focused on PWSRCAC contributions as much as possible. The outcome framework analysis illustrates that PWSRCAC reduced risk related to every IRGC risk factors examined (Figure 8). No quantitative or qualitative weight was given directly to mark the degree of change.

The widespread improvement of the IRGC risk factors indicates that PWSRCAC has increased the resiliency of the risk governance system. While all of the IRGC risk factors improved, some broader trends merit specific mentioning. First, PWSRCAC ***lowered the known uncertainty*** by creating its own assessments, entering collaborative projects, and strengthening regulatory incentives. Second, it has proposed, supported, and implemented ***numerous safeguards*** to interfere with the most vulnerable risk pathways in the system and buffer for unknown risks. Third, PWSRCAC has ***promoted stronger integration*** among stakeholders to better ***manage irreducible uncertainty*** and ***alleviate value conflicts***. Adding diverse perspectives has created a ***broader systems perspective*** that is necessary to identify system weaknesses located on the peripheral. ***Increased communication*** among participants has enabled the system to be more responsive to new information or risks. In combination, the risk governance system has become more ***adaptive*** and ***resilient*** due to the presence of PWSRCAC.



IRGC Risk Factor	Risk Context (Before EVOS)	Outcome (After PWSRCAC)	Change
Scientific Unknowns	Underestimated Risk Predictions, Limited Response Information, Unknown Technological Impacts	Improved Contingency Plans, Long-term Environmental Information, Attention to Human Errors, Identification of Unrecognized Risks, Abundant Scientific Research	**Significant Improvement**
Loss of Safety Margins	Tight coupling, Inadequate Regulation, Limited Technological Safeguards, Insufficient Response Plans/Equipment	Abundant Safeguards, Improved Compliance Enforcement, Innovative Safeguard Technology, System Redundancy, Greater Stakeholder Coordination	**Significant Improvement**
Positive Feedback & Communication	One-way Communication, Lack Response to Public Concerns, Conflict Distractions, Ignored Safety Recommendations, Lack of Response Coordination	Multi-directional Communication, Coordinated Plans and Activities, Greater Response to Concerns	**Significant Improvement**
Varying Susceptibilities to Risk	Coastal Communities, Fisherman, and Indigenous Populations at High Involuntary Risk	Procedural Fairness, Attention to Local Risk, Increased Local Capacity, Empowerment Vulnerable Populations	**Improvement**
Conflicts about interests, values, science	Pervasive Conflicts, Contested Risk Assessments, Duplicate Studies, High Distrust, Limited Consultation	Collaborative risk assessments, Increased Stakeholder Trust, Mutual Understanding, Unified Risk Acceptance, Resource Sharing, Unveiled Assumptions/Uncertainty	**Significant Improvement**
Social Dynamics	Adversarial Relationships, Image Manipulation, Limited Transparency, Limited Public Relations for Response, Public Protests	Broader Stakeholder Inclusion, Information Sharing, Education Programs, Involvement at Community Events, Public Volunteering, Ongoing Public Information Hub	**Improvement**
Technological Advances	Limited Incentive for Safeguards	Innovative Safeguards, Adaptive Management, Greater Research	**Significant Improvement**
Temporal Complications	Gradual Decrease of Vigilance, Promoting No Spills and Safety Signal, Regulatory Budget Cuts, Safeguard Reductions	Deterred Complacency, Maintain Regulatory Budgets, Regular Safety Reviews	**Significant Improvement**
Information Asymmetries	Limited Public Access, Resource Discrepancies, Lack Transparency	Greater Public Access, Abundant Non-Industry Information, Fact Checking, Public Education	**Significant Improvement**
Main Features	Multiple Interacting Systems, High Complexity, Irreducible Uncertainty, Enduring Conflict, Challenging Temporal Conditions	Reduced uncertainty, Increased firewalls, Improved Communication Feedback, Alleviated Conflict, Deterred Complacency	**Adaptive, Resilient, Systems Perspective**

Figure 9. IRGC Risk Factor Analysis Summary and Comparison (Risk Context = Before EVOS, Outcomes =After PWSRCAC)

IV. Conclusions

The retrospective multi-framework analysis identifies the critical context, development, and design factors that have successfully shifted a risk governance system towards the new risk paradigm (Figure 10). The critical development factors that made the risk governance shift feasible for the case study are large barriers for other mineral industry systems. These critical development factors include the EVOS focusing event, the empirical basis, financial resources, leadership, public motivation, and policy familiarity. The role of impetus and need for more supportive social capacity are likely to be some of the biggest challenges in the transition of other systems.

The design and contextual factors might be more controllable and/or identifiable. The design components that most influenced risk outcomes include representation, independence, transparency, resource accessibility, collaborative capacity, and institutionalization. General contextual conditions within the risk system include tight coupling among multiple systems, high complexity, irreducible uncertainty, enduring conflict, and challenging temporal conditions.

Framework	Guiding Questions	Critical Factors
Risk Context	When is the RCAC model for risk governance necessary or appropriate? Under what conditions?	Multiple Interacting Systems, High Complexity, Irreducible Uncertainty, Low Predictability, Enduring Conflict, Challenging Temporal Conditions (Infrequent, Lag Time, etc.), Limited Communication Feedback, High Public Distrust
Development	What social and political factors are needed to make the elaborate shift to a new risk governance paradigm feasible?	Impetus (Mutual Motivation, Interdependency, Recognized Legitimacy, Dedication to Trust Building), Empirical Basis, Financial Resources, Public Leadership, Motivated Public, Policy Familiarity
Design	How should the new public participation institutions be designed (process, structure, resources)?	Representation, Independence, Transparency, Resource Accessibility, Collaborative Capacity, Institutionalization
Outcomes	How has the system risk changed?	Reduced Uncertainty, Increased Firewalls, Increased Communication Feedback, Alleviated Conflict, Deterred Complacency, Improved Adaptive Capacity, Created Broader Systems Perspective

Figure 10. Multi-Framework Analysis Critical Factors Summary

The intent of the study is not to suggest a prescriptive risk governance structure that will work for all complex and uncertain risks. In fact, the analysis acknowledges that complex risks vary widely and a prescriptive mechanism is inappropriate. Moreover, the PWSRCAC is not a perfect example of risk governance or participatory inclusion. PWSRCAC is an elaborate participatory institution, but its role is limited to advisory. Financial resources are necessary to generate the supporting evidence that can leverage successful implementation of recommendations (Busenberg 2007). Additionally, PWSRCA and other stakeholder groups continue to rely on traditional quantitative risk assessments to inform risk management decisions. The tug escort collaborative and human risk factor analysis are examples that unveil value judgments and broaden assessment criteria, but these are not the norm. Most PWSRCAC recommendations are based on independent risk assessments by external consultants. Finally, the inclusion of PWSRCAC in the risk governance system could increase risk management costs and/or delays. The current analysis does not examine financial or time efficiency.

Regardless, the PWSRCAC model should be considered for tailored implementation in other complex risk systems that have similar risk management challenges. The multi-framework analysis illuminates critical factors to consider when determining when and how to design a new risk governance system. Currently, there are abundant complex risk issues that involve overlapping technological and environmental systems. All of these risks systems challenge the traditional risk paradigm and surrounding governance institutions to adequate manage risks. Future research should evaluate the potential implementation within other systems.

There are some systems that have already proposed using the PWSRCAC model to manage such challenges. For instance, expansion of the Alaskan RCACs jurisdiction to include the upstream pipeline infrastructure has been repeatedly advocated and considered among stakeholders (AEDC 2010). The prospect of such expansion indicates a certain level of perceived success within the region. If implemented, it would provide a more specific model for pipeline risks in other areas.

The PWSRCAC model has also been proposed in the wake of the BP Deepwater Horizon Oil Spill. Communities throughout the region have worked closely with representatives from the Alaskan RCACs to leverage past development and design experience (PWSRCAC 2010). In January 2011, The President's National Commission on the BP Deepwater Horizon released a final report that recommends the creation of Regional Citizen Advisory Councils (RCACs) similar to those established by OPA 90 (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling 2011). However, at this time, there has not been a legislative mandate for a RCAC that would permanently work with industry and regulators on enduring risk management activities.

Other technological risk systems, particularly those experiencing rapid innovation, should also consider the implications of the PWSRCAC case study. Steiner (2011) has advocated using the Alaskan RCAC model for mines across the Pacific. However, there is no reason that they should not be considered in other areas as well. For example, one pertinent state issue involves copper mining development in northeastern Minnesota. Innovative technology has opened new economically feasible reserves of low grade copper ore in an ecologically sensitive region of the state. The project proposes safeguards to prevent environmental contamination, but the safeguards have never been tested in the region's water-rich system (MPR 2012).

Another prevalent issue nationally involves the use of hydraulic fracturing to extract oil and gas from shale formations. The process injects undisclosed chemicals mixed with sand and water underground to cause shale fissures that release oil and/or gas. There are rising concerns related to aquifer contamination, wastewater disposal, and earthquakes (Rozell and Reaven 2011). However, science and value conflicts among stakeholders continue to delay policy decisions (New York Times 2012).

Oil transportation, copper mining, and natural gas extraction all have unique risks that vary widely in the contextual details. However, they all share broad commonalities related to risk governance challenges. Each scenario described involves complex relationships, uncertain consequences, and adversarial stakeholders. These contextual components suggest that risk governance could improve management outcomes by shifting towards the new risk paradigm that incorporates greater public participation.

Despite the growing number of complex technological and environmental risks, numerous barriers continue to restrict widespread adoption of a more participatory risk governance approach. The PWSRCAC case study indicated that institutionalize public participation is a critical design factor that contributes to positive risk outcomes. However, new participation institutions will require exigent institutional changes. Moreover, the case study supports the notion that other supporting sociopolitical factors that are necessary for successful implementation. A focusing might be necessary, but does not appear to be sufficient alone. These results are consistent with previous research examining the role of focusing events and governance change (Kurtz 2004).

Without a crisis to create the impetus, stakeholders may lack the necessary incentives to voluntarily move towards a new governance system. The public may lack leadership and motivation to champion new institutions specifically designed for them. Political will may be limited by jurisdiction complications in the region. Multi-state jurisdiction over technological or environmental risks makes coordination even more complicated because of the inherent mixed motivations and resource asymmetries (Hassler 2011).

It is interesting that many of the oil companies in the PWS risk governance system are also involved in other technological and environmental risks around the nation. While PWSRCAC appears to have the oil industry support, these oil companies are not embracing other elaborate public partnerships. One reason could be that PWS has specific environmental hazards, such as icebergs, that highlight the inherent vulnerabilities in the system. Industry may not perceive or acknowledge the vulnerabilities in other risk systems that may warrant broader involvement. Also, industry experience in the PWS risk governance system may link public partnerships with lower economic efficiency. The current case study does not attempt an analysis to determine whether industry has achieved optimal economic risk. Future studies should examine financial costs and time delays within the PWSRCAC risk governance system. Comparing different regional motivations that impede and encourage development of the new risk paradigm would also be valuable research for future studies.

Another barrier that restricts greater integration of the public is a lack of clear evidence regarding the potential benefits and appropriate design. This multi-framework analysis is an example how research is moving towards a more interdisciplinary and systems approach. However, additional work is greatly needed to address the new questions raised and overcome current analysis limitations. The acknowledged limitations of this study are described below.

There are several assumptions used in the retrospective multi-framework analysis conducted in this study. First, the case study was chosen to exemplify a successful risk governance structure that leverages broader perspectives in the decision-making processes. Ideally, success would be defined as less oil spill frequency and severity of impacts. However, major oil spills are low probability events that are difficult to predict and illustrate in trends, especially over a short time period. Since non-events cannot be analyzed, it is impossible to determine if the PWSRCAC presence has directly prevented oil spill incidents or severity of effects. However, the outcome analysis illustrates how the factors that often contribute to overall risk have been reduced since the PWSRCAC creation.

Second, PWSRCAC was one of numerous policy and institutional changes that took place after the EVOS. Undoubtedly, these other policies have contributed to significant risk reductions in the risk governance system as well. The analysis does not intend to credit PWSRCAC for all the improvements that have taken place since EVOS. In fact, the outcome framework analysis focuses on the direct contributions of

PWSRCAC as much as possible. However, most outcomes have multiple driving forces that could not be separated. PWSRCAC is often a major driver, but not always the only one.

As has been acknowledged throughout this paper, there are contextual limitations that impede the transfer of analysis implications to other risk systems. In addition to the specific contextual differences between risks systems, unknown conditional thresholds limit the transferability of current implications. Many risk systems have acknowledged complexity, uncertainty, and adversarial social dynamics. However, the current analysis does not clarify the critical thresholds is for high complexity, uncertainty, and/or conflict that warrant greater public inclusion in risk governance. It is possible that all of these risk systems could benefit from new forms of public participation. The problem remains the complicated alignment of the contextual conditions, developmental capacity, and functional design.

Complex and uncertain risks continue to be pervasive throughout modern society. These risks demand new decision making processes and management models that can procure the benefits of technological opportunities without inflicting unnecessary environmental and social harm. Values and uncertainty need to be unveiled and systematically integrated with science to inform policy decisions. While, science is absolutely necessary, it is insufficient on its own.

The PWSRCAC case study presented in this paper shows how the risk governance system can shift towards the new risk paradigm that integrates science and values. It further illustrates how broader public participation in risk governance can lower risk and increase system resiliency. The new risk governance system has successfully reduced uncertainty, increased firewalls, improved communication feedback, alleviated conflict, and deterred complacency. This case study demonstrates the potential benefits of the new risk paradigm and the critical factors that should be considered for transferred success.

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